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Robin Jarrett of Los Angeles, CA. See R. Peigler article, page 72.

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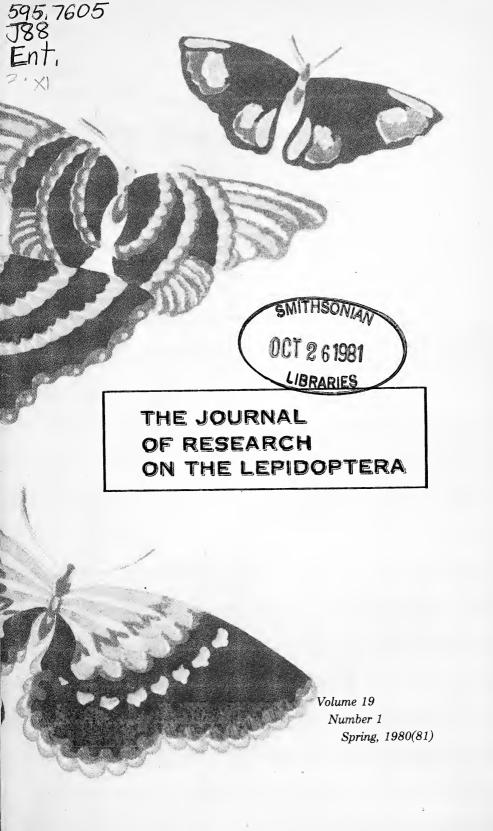
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COVER ILLUSTRATION: Left to right, pupae of  $Battus \ polydamas$ ,  $Parides \ bunichus$ ,  $P. \ anchises \ nephalion$ ,  $P. \ agavus$  and  $P. \ proneus$ , three views.



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William Hovanitz

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Manuscripts may be sent to the Editor at: 9620 Heather Road, Beverly Hills, CA 90210 (213) 274-1052

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## Butterflies of Clark County, Nevada

George T. Austin and Anna T. Austin

Nevada State Museum, Capitol Complex, Carson City, Nevada 89710 and 5077 Eugene Avenue, Las Vegas, Nevada 89108

Abstract. Clark County, the southernmost area of Nevada is in the northern portion of the Mojave Desert. This area is topographically diverse and with several distinct biotic communities. The butterfly fauna is also diverse with 125 taxa recorded within the county. Of these, at least 15 are non-resident strays. Five subspecies of widely ranging polytypic species are endemic. Over forty percent of the species have distributions mainly in the North American deserts; most of the remaining species are more widespread.

Butterflies have been recorded in all months but are most abundant from May through July. Of the species for which voltinism is known, more than one-third are univoltine, one-fifth are bivoltine and the remainder are multivoltine. The number of broods varies somewhat with habitat and elevations and, in some species, on the occurrence of summer rainfall.

### Introduction

The distribution and occurrence of butterflies in Nevada are poorly known and there is very little literature pertaining to the state's butterfly fauna (Field et al. 1974). The only regional list is for the Carson Range in the western part of the state (Herlan 1962). There is also a recent list of the species known from the state (Harjes 1980). The butterfly fauna of adjacent California is known for the Mojave Desert in southeastern California (Emmel and Emmel 1973). Those of adjacent Arizona and Utah are known less well (Haskin 1914, Tidwell and Callaghan 1972). Nevada records are largely scattered through the literature, listed in the seasonal summaries published by the Lepidopterists' Society, in the Nevada State Museum and in various other collections.

We have resided in Las Vegas continuously since 1961. Our records and those of others who have lived in or visited the area are now sufficient to allow publication of an account and analysis of the county's butterflies.

Our private collection forms the basis for this report. In addition, the senior author has examined in whole or part several collections and has

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corresponded with others who have collected within the state. Over 13,000 specimens were viewed.

For each taxon, we briefly discuss what is known of its distribution, phenology and ecology in the county and, where pertinent, taxonomic comments and comparisons. Following this we list specimens examined, other reported occurrences, larval foodplants recorded in Clark County and resources used by adults. Specific records are not listed for many of the very common species except for certain species of interest or for unusual distributional or seasonal occurrences. Specimens examined are those actually seen by the senior author in his visits to various collections or those seen while in the field with other collectors (total number given first in parentheses). Numbers, distribution among the sexes and collection are indicated. Additional records include specimens reported to us by other collectors, sight records (largely by the senior author) and reports in the literature or seasonal summaries of the Lepidopterists' Society. Specimens in other collections are credited to the person (or institution) who maintains the collection and, if different, the person who reported the specimen to us. Sight records are indicated by an "s" following the observer. Literature citations are presented in the usual form. Records from the seasonal summaries are cited by the year of the summary (summ.) which is normally published in the second number of the News of the Lepidopterists' Society of the following year with occasional addenda in later numbers. Specimens reported in the summaries that were later seen are included under specimens examined. Foodplant records are those of the authors unless indicated otherwise and are categorized as adult association (adult assoc.), oviposition (ovip.), larvae and, in a few special cases, pupae. Adult resource (flowers, unless indicated otherwise) observations were entirely by the authors. Plant identifications were mostly by botanists at the University of Nevada, Las Vegas; plant nomenclature largely follows Munz and Keck (1963) and Beatley (1976). Time of day is based on the 24 hour clock (PST).

Butterfly nomenclature used herein follows dos Passos (1964) and later revisionary works where applicable. All comparisons and taxonomic determinations were made by the senior author. Low elevations generally pertain to "desert" below the Piñon-Juniper belt (ca. 6000') and high elevations are above 6000' in montane woodland and forest.

Collections which were examined or from which records were reported are as follows: D. E. Allen (DEA), R. Bailowitz (RB), A. Bean (AB), J. Brock (JB), Carnegie Museum (CM), D. Eff (DE), J. F. Emmel (JFE), C. D. Ferris (CDF), C. F. Gillette (CFG), P. J. Herlan (PJH), H. L. King (HLK), J. Lane (JL), R. L. Langston (RLL), C. S. Lawson (CSL), J. F. Leser (JFL), Los Angeles County Museum (LACM), C. D. MacNeill (CDM), D. Mullins (DM), Nevada State Museum (NSM), F. W. Preston (FWP), K. Roever (KR), J. A. Scott (JAS), O. Shields (OS), R. E. Stanford (RES), K. B.

Tidwell (KBT), University of Nevada, Las Vegas (UNLV), and R. E. Wells (REW). Additional Nevada records were supplied by C. Henne and B. McGuire.

A number of specimens, some important, in the Nevada State Museum from the Arrow Canyon Range (apparently west slope off U. S. 93) bear no collection date. The museum card catalog lists the date 13 May 1969 for some of these. We believe the correct date for all these undated specimens to be 14 April 1969 based on (1) 2 Heliopetes ericetorum labeled Arrow Canyon Range, 14 April 1969, (2) the date of 14 April 1969 was reported for certain of these specimens in the 1969 summary, (3) other collections were made in Clark Co. on 12 April 1969 (Searchlight, McCullough Mts., Blue Diamond) and (4) no specimens from Clark Co. (except 2 Euphilotes battoides baueri which may be mislabeled) with the date 13 May 1969 could be found in the museum. The only other reference to the 13 May date is of a collection of "P. mojave" (= E. battoides baueri) in the Delamar Mts., Lincoln Co. (1969 summ.).

### **Description of Clark County**

Clark County is located in southernmost Nevada in the northern portion of the Mojave Desert. Several distinct biotic communities occur in the county due to great topographic diversity with elevations ranging from about 500' along the Colorado River to nearly 12,000' on Charleston Peak in the Spring (Charleston) Mountains. The biotic communities of southern Nevada were described in some detail by Bradley and Deacon (1965). Important works dealing with plant distribution in the county include Clokey (1951) and Beatley (1976). Brief descriptions of the major vegetative associations follow.

Most of Clark County (78%, Bradley 1967) is dominated by xerophytic vegetation. The largest association is the creosote bush community which occurs at elevations below 4200' and is dominated by creosote bush (Larrea tridentata) and burrobush (Ambrosia dumosa). Numerous other shrub species are subdominant and many species of annual plants occur. At the higher elevations of this association there are often stands of Yucca. Density and diversity of plants tend to increase along desert washes. Along some major washes is a distinctive association of greater stature dominated by mesquites (Prosopis spp.) and catclaw (Acacia greggii). At elevations between 4200' and 6000', the desert vegetation is characterized by blackbush (Coleogyne ramosissima) with Joshua Tree (Yucca brevifolia) as a subdominant in some areas.

Elevations between 6000' and 7300' are dominated by a woodland characterized by Pinon (*Pinus monophylla*) and juniper (*Juniperus osteosperma*) often with an understory of sagebrush (*Artemisia* spp.). A distinct association including such species as silk-tassel (*Garrya flavescens*), manzanita (*Arctostaphylos pungens*) and oak (*Quercus gambelli*) develops

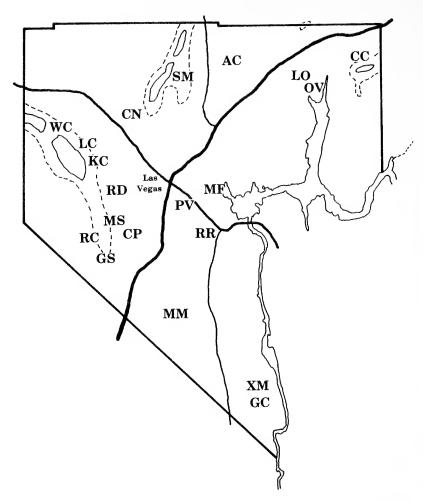


Fig. 1. Map of Clark County, Nevada, indicating major collecting localities mentioned in the text. Contour lines indicates 6000' (dotted line) and 7500' (solid line) elevations.

AC - Arrow Canyon Range MM - McCullough Mountains CC - Cabin Canyon MS- Mt. Springs Summit CN - Corn Creek OV - Overton area CP - Cottonwood Pass PV - Paradise Valley GC - Grapevine Canyon RC - Red Cloud Mine RD - Red Rock area GS - Goodsprings area KC - Kyle Canyon RR - Railroad Pass LC - Lee Canyon SM - Sheep Mountains LO - Logandale WC - Willow-Cold Creek area MF - Mormon Farm XM - Christmas Tree Pass

in disturbed areas. At elevations above 7300', there is a forest community composed of Ponderosa Pine (Pinus ponderosa) and White Fir (Abies concolor) at lower elevations and Limber and Bristlecone pines (Pinus flexilis and P. aristata) becoming commoner at higher elevations. Understory shrubs include current (Ribes spp.), snowberry (Symphoricarpos longiflorus) and Mountain Mahogany (Cercocarpus ledifolius).

Other associations include relatively small areas but are important as butterfly habitat. Cultivated and urban areas are found at low elevations, principally in Las Vegas, Virgin and Moapa valleys. Marsh vegetation develops in the presence of permanent water in such areas as Las Vegas Wash, Tule Springs, Corn Creek and in Moapa Valley.

Distinctive riparian associations develop in the vicinity of permanent water at high elevations, notably at Little Falls in Kyle Canyon and at Willow and Cold creeks in the northern portions of the Spring Range. Meadows also occur in some cleared or naturally open areas at high elevations including the old ski area in Kyle Canyon, along the ridge to Charleston Peak and in the vicinity of the ski area in Lee Canyon.

In certain areas, especially on the east slope of the Spring Range in the Red Rocks area, vegetation zonation is depressed in elevation in some deep, cool canyons with permanent water. This results in a unique mixture of vegetation not found in other portions of the county.

### **Annotated List of Species**

In the following listing where no initials are given it will be assumed that the records were made by G. T., A. T. and E. J. Austin. Otherwise, the record citation will be indicated by the abbreviated collector or collection name. Males and females in the numerical listing are cited as "m" and "f" respectively. The locality citations are abbreviated according to the legend given with Figure 1.

### Family Megathymidae

Agathymus alliae (Stallings & Turner) ssp.

Locally common only in the vicinity of Agave at middle elevations. The single brood flies from late September to early November. Clark County material belongs to the unnamed eastern Mojave Desert population as illustrated in Emmel and Emmel (1973).

SPECIMENS EXAMINED: (41) 1 mi. W. MS, 28 Sept. 78 (9 m), 30 Sept. 79 (4 m), 10 Oct. 78 (10 m, 1 f), 11 Oct. 77 (1 m, 3 f), 22 Oct. 77 (5 m, 3 f), 2 Nov. 77 (4 f); CC, 11 Oct. 78 (1 m).

ADDITIONAL RECORDS: 1 mi. W. MS, 1 Oct. 77 (s).

LARVAL FOODPLANTS: Agave utahensis Engelm. var. nevadensis Engelm. ex Greenm. & Roush. (Agavaceae): 1 mi. W. MS (larval tubes).

ADULT RESOURCES: m at water.

Megathymus yuccae navajo Skinner.

Uncommon in the higher desert to about 6000' in stands of Yucca. The flight period is from early March to late May. Clark County material is assigned to the

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broad concept of *navajo*. In a more strict sense, these insects appear closest to *M. y. maudae*. Stallings, Turner & Stallings.

SPECIMENS EXAMINED: (15) Newberry Mts., 15 Mar. 69 (1f, NSM); CC, 13 April 78 (1f, CSL), 27 April 78 (1 m; 1 m, CSL); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 16 April 79 (2 m, 1 f), 29 April 79 (1 f), 2 May 78 (1 m), 6 May 78 (1 f, CSL), 28 May 78 (1 m); KC 17.1 mi. W. U.S. 95, 26 Apr. 77 (1 m); 1 mi. W. RD Summit, 28 April 77 (1 m, NSM); 2 mi. N. RC, 4 May 78 (1 m); KC Ski Run, 13 May 78 (1 m).

ADDITIONAL RECORDS: Dead Mts., 7 Mar. 67 (PJH); Willow Spring, 29 Mar. 78 (s); Wilson Pass, 29 Mar. 78 (s); CP to Pahrump Rd., 29 Mar. 78, 20 Apr. 77, 29 Apr. 78, 11 May 78 (s); 2 mi N. RC, 5 Apr. 78 (s); 2 mi N. Sandy, 5 Apr. 78 (s); Potosi Mine Rd., 8 Apr. 71 (REW); CC, 8 Apr. 77 (RB), 10 May 78 (s); XM, 12 Apr. 78, 20 Apr. 78, 3 May 78 (s); GC, 12 Apr. 78 (s); KC, 9-17 mi. W. U.S. 95, 17 Apr. 66, 18 Apr. 77, 1 May 77, 13 May 78 (s), 28 May 73 (JFL); U.S. 93, 8 mi. N. I-15, 20 Apr. 75 (s); GS area, 20 Apr. 75 (JB); RD Summit Rd., 1.5-1.8 mi. E. Lovell Wash, 24 Apr. 77, 28 Apr. 77 (s); WC, 27 Apr. 77 (s); 1 mi. W. WC, 8 May 78 (s).

LARVAL FOODPLANTS: Yucca baccata Torr. (Agavaceae): Spring Mts., 30 Sept. 68 (larvae, 1968 summ.); RD, 25-27 Mar. 78 (pupae, REW); 1 mi. W. WC, 8 May 78 (ovip.). Yucca schidigera Roezl ex Ortgies (Agavaceae): RD, 25-27 Mar. 75 (pupae, REW); Charleston Blvd. nr. RD, 25 Nov. 78 (3 larvae in feeding tents, DM).

### Family Hesperiidae

Lerodea eufala (Edwards).

Common to abundant in agricultural areas of Las Vegas, Moapa and Virgin valleys with occasional records in the vicinity of desert springs and rarely in open desert (Railroad Pass). The flight period extends from early May through mid November; it becomes increasingly common in successive broads suggesting poor overwinter survival. Four broads were produced at about 45 day intervals in the Logandale area but only 2 or 3 broads in other areas during 1977.

SPECIMENS EXAMINED: (333) Numerous records for Moapa Valley with earliest on 7 May (78, 1 m, CSL) and latest on 11 Nov. (77, 3 m, 5 f). Records away from Moapa Valley area: Las Vegas, 19 June 78 (1 m, CSL); MF, Las Vegas, 14 Aug. 77 (1 m), 13 Sept. 77 (1 m, 1 f), 25 Sept. 77 (1 m, 3 f), 30 Sept. 77 (1 m, 1 f), 2 Oct. 77 (13 m, 8 f), 13 Oct. 77 (1 m), 16 Oct. 77 (1m), 21 Oct. 77 (2 m), 1 Nov. 77 (1 m); Mesquite, 18 Sept. 72 (3 m, 4 f, NSM); 0.6 mi. W. Blue Diamond, 26 Sept. 77 (1 m); RR, 3 Oct. 77 (1 m); Virgin Mts., 7 Oct. 73 (1 m, 3 f, NSM); CN, 7 Oct. 77 (1f). The only high elevation record is for WC, 23 Sept. 77 (1 f).

ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Polygonum lapathi-folium (Polygonaceae); Convolvulus sp. (Convolvulaceae); Medicago sativa (Fabaceae); Helianthus annuus, Bebbia juncea, Pluchea sericea (Asteraceae).

Atrytonopsis python (Edwards).

A single record from Pine Creek is the only one for Nevada.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: Pine Creek, 30 June 63 (KR).

Ochlodes yuma (Edwards).

Locally common in or near stands of *Phragmites communis* flying in 2 broods with peaks in late June (early June-early August) and in late September (late August early November). It rarely strays far from these situations although it is found commonly in alfalfa fields adjacent to *Phragmites* stands in Moapa Valley.

SPECIMENS EXAMINED: (190) Hidden Valley, 7 June 77 (1 m), 15 June 77 (5 m), 27 June 77 (5 m, 2 f), 4 July 77 (2 m), 12 July 77 (1 m), 25 Sept. 66 (1 m); PV, 9 June 79 (1 m, 1 f); Whitney Mesa, 9 June 79 (1 m), 6 Sept. 77 (3 m), 30 Sept. 77 (4 m, 2 f), 12 Oct. 77 (1 m), 21 Oct. 77 (1 m); CN, 12 June 66 (4 m, 2 f), 22 June 68 (5 m, 8 f), 18 July 65 (6 m, 7 f), 8 Aug. 77 (1 m, 3 f), 1 Sept. 63 (2 m, LACM), 3 Sept. 75 (14 m, NSM), 10 Sept. 75 (13 m, NSM), 15 Sept. 64 (4 m, 2 f, NSM), 25 Sept. 65 (4 m, NSM), 7 Oct. 77 (8 m, 4 f), 14 Oct. 77 (3 m, 3 f), 4 Nov. 77 (1 m, 1 f), 12 Nov. 77 (1 f); LO, 15 June 77 (12 m, 4 f), 27 June 77 (10 m, 1 f), 4 July 77 (5 m, 1 f), 12 July 77 (1 f), 30 July 77 (1 m), 23 Aug. 77 (2 m), 9 Oct. 77 (1 m, 4 f), 23 Oct. 77 (2 f); Bowman's Reservoir, 27 June 77 (1 m); Tule Springs, 4 July 62 (3 m); Clark County, 9 Sept. 76 (1 f, UNLV), 15 Sept. 73 (1 f, UNLV); Arden, 15 Sept. 64 (1 f, NSM), 25 Sept. 65 (1 m, NSM); Roger's Spring, 15 Sept. 64 (2 m, NSM); OV, 15 Sept. 64 (1 f, NSM); 25 Sept. 65 (1 f, NSM), 27 Sept. 65 (2 m, NSM); Valley of Fire, 27 Sept. 65 (1 m, NSM); Warm Springs, 27 Sept. 65 (1 m, NSM); Las Vegas, 2 Oct. 75 (1 m, UNLV), 10 Oct. 70 (1 m, UNLV), 15 Oct. 75 (1 f, UNLV).

ADDITIONAL RECORDS: LO, 7 June 77 (s), 10 July 72 (1972 summ.); Roger's Spring, 22 June 65, 25 Sept. 65 (PJH); CN, 22 June 68, 29 June 72 (JFL), 29 June 63 (KR), 31 July 65 (RES), 1 Aug. 65 (RES, JL), 1 Sept. 63 (KR); Tule Springs, 29 June 63 (KR); Cold Creek, 29 June 63 (KR); Hidden Valley, 4 Sept. 77 (s).

LARVAL FOODPLANTS: Phragmites communis Trin. (Gramineae): adult assoc. nearly everywhere found.

ADULT RESOURCES: Heliotropium curassavicum (Boraginaceae); Prosopis pubescens, Medicago sativa (Fabaceae); Solidago spectabilis, Pluchea sericea, Cirsium sp. (Asteraceae).

Atalopedes campestris (Boisduval).

Uncommon in agricultural areas of Moapa Valley (one record for Las Vegas Valley) flying in 2 broods during July and October. There are no other Nevada records.

Nevada material is consistently smaller than east coast and Texas specimens and tends to be more heavily patterned on the hindwing beneath and the females have considerably more orange above. They appear identical with a small series we have from the Sacramento Valley, California and may warrant subspecific recognition.

SPECIMENS EXAMINED: (22) LO, 4 July 77 (1 m), 10 July 68 (3 m), 9 Oct. 77 (4 m, 2 f), 16 Oct. 77 (3 m, 3 f), 23 Oct. 77 (2 m); MF, 2 Oct. 77 (1 m); OV, 23 Oct. 77 (3 m).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Medicago sativa (Fabaceae).

Polites sabuleti (Boisduval) ssp.

Locally common, especially in fall, in agricultural areas and occasionally in low alkali areas. One record for higher elevations at Mt. Springs Summit. Flies apparently in three broods in April, June-July and early August to early November.

We refrain from placing southern Nevada material in any named race. Our material is highly variable ranging from pale specimens with the hindwing markings beneath nearly lost in the pale ground color which resemble *P. s. chusca* (Edwards) to dark individuals from the same location and date with the markings on the lower hindwing well developed and thus approaching nominate *sabuleti*.

SPECIMENS EXAMINED: (96) PV, 14 April 77 (1 m, NSM); 10 mi. W. Glendale Jct., 17 April 70 (1 f, NSM); MF, 30 April 77 (1 m), 25 June 77 (1 m, 1 f), 14 Aug. 77 (2 f), 3 Sept. 77 (8 m, 3 f), 13 Sept. 77 (6 m), 25 Sept. 77 (4 m, 2 f), 2 Oct. 77 (18 m, 11 f), 16 Oct. 77 (1 f), (1 f); LO, 17 May 78 (1 m), 10 July 68 (1 m), 4 Sept. 66 (1 m), 28 Sept. 67 (1 m, 1 f, NSM), 9 Oct. 77 (1 m, 3 f), 16 Oct. 77 (1 m, 3 f); OV, 4 Sept. 66 (1 f), 26 Sept. 65 (3 m); Bowman's Reservoir, 7 May 78 (1 f, CSL), 27 Sept. 78 (1 m), 29 Sept. 66 (1 f, NSM), 29 Sept. 77 (2 m), 27 Oct. 65 (3 m, NSM); CN, 15 Sept. 64 (8 m, 1 f, NSM); OV, 27 Sept. 78 (1 m); Willow Springs, 24 Oct. 65 (1 m).

ADDITIONAL RECORDS: CN, 22 June 68 (KR), 10 Sept. 75 (CSL), 7 Oct. 77 (s); MS, 30 June 63 (KR); Clark County, 8 Aug. 74 (JAS); LO, 23 Aug. 77, 17 Sept. 77, 23 Oct. 77 (s); MF, 24 Aug. 77, 30 Sept. 77, 21 Oct. 77 (s); GC, 14 Sept. 77 (s); Whitney Mesa, 30 Sept. 77 (s); OV, 23 Oct. 77, 5 Nov. 77 (s).

ADULT RESOURCES: Polygonum lapathifolium (Polygonaceae); Convolvulus sp. (Convolvulaceae); Heliotropium curassavicum (Boraginaceae); Medicago sativa (Fabaceae); Baccharis sp. (Asteraceae).

Polites draco (Edwards).

A male from Kyle Canyon is the only record for the state.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: KC, 16 June 77 (J. W. Tilden, det. CDM, RES.). Hesperia comma harpalus (Edwards).

Not uncommon in the Spring Range from 6000' to 9000'. It flies in apparently two broods from mid May to early August and late August to late October. Spring Range material is large and quite orange above and thus differing from Great Basin populations and possibly showing some influence of *H. c. susanae* Miller. Its double broodedness appears unique among *harpalus*.

SPECIMENS EXAMINED: (140) Numerous records especially in KC and the WC area with records between 12 May (1934, Charleston Mts., 1, LACM) and 24 Oct. (1977, KC Ski Run, 1).

ADDITIONAL RECORDS: LC, 29 May 50 (MacNeill 1964), Charleston Peak trail, 10,800-11,918', 24 June 68 (JFE, OS); KC, 6768', 30 June 50 (18 m, 12 f, FWP); Deer Creek Rd., 7000', 1 July 50 (4 m, 8 f, FWP); KC Campground, 2 July 78 (s); KC Ski Run, 2 July 78, 25 July 78, 8 Oct. 77 (s); Charleston Park, 8-15 July 28 (MacNeill 1964); LC Ski area, KC, Deer Creek area, 8 Aug. 74 (JAS).

ADULT RESOURCES: Apocynum androsaemifolium (Apocynaceae); Sarcostemma cynachoides (Asclepiadaceae); Penstamon palmeri (Scrophulariaceae); Chaenactis douglasii, Chrysothamnus sp., Cirsium sp., Taraxacum officinale (Asteraceae).

Hesperia nevada (Scudder).

A single specimen of the western Great Basin population of this species is known from Clark County.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: Charleston Mts., 13 May 31 (MacNeill 1964).

Hesperia pahaska martini MacNeill.

The only records are from the Sheep Range. Its reported foodplant, *Tridens pulchellus*, is widespread in the county and the presence of other colonies is probable.

SPECIMENS EXAMINED: (3) Sawmill Canyon, E. side of SM, 6000-6500', 1 July 69 (1 f, LACM), 2 July 69 (1 m, 1 f, LACM).

#### ADDITIONAL RECORDS: None.

Hesperia juba (Scudder).

Rare above 6000' in the Spring Range and in the Virgin Mts. with records indicating two broads from late May to mid July and late September to late October.

SPECIMENS EXAMINED: (7) WC, 6 June 78 (1 f), 22 June 78 (1 f); CC, 7 June 78 (1 f, CSL); KC Ski Run, 15 July 79 (1 f, CSL); KC, 9 Oct. 66 (1 m, 1 f); Echo Canyon, 23 Oct. 66 (1 f).

ADDITIONAL RECORDS: Charleston Park, 29 May 50 (MacNeill 1964); LC, 29 May 50 (MacNeill 1964); Cold Creek, 29 June 63 (KR); Cathedral Rock, 12 July 72 (DEA); KC, 26 Sept. 65 (PJH).

Hylephila phyleus (Drury).

Common to abundant in urban and agricultural areas, less common in the vicinity of desert springs. It is rare away from these situations with occasional records for desert washes in fall and two records for high elevations. The flight period is from late March to mid December.

SPECIMENS EXAMINED: (364) Many locations in Las Vegas and Moapa valleys with a small population in GC. Dates extend from 31 Mar. (78, PV, s) to 15 Dec. (79, Las Vegas, CSL). A sexual mosaic was taken at Hidden Valley on 23 Oct. 77.

LARVAL FOODPLANTS: Cynodon dactylon (L.) Pers. (Gramineae): Las Vegas, 7 June 77 (ovip.).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Sarcostemma hirtellum (Asclepiadaceae); Heliotropium curassavicum (Boraginaceae); Prosopis glandulosa, Medicago sativa (Fabaceae); Viguiera deltoidea, Bebbia juncea, Baileya multiradiata, Perityle emoryi, Senecio douglasii, Baccharis sp., Cirsium sp., Stephanomeria sp. (Asteraceae).

Copaeodes aurantiaca (Hewitson).

Fairly common in urban and agricultural areas, less common and somewhat local in desert washes and around springs and rare at high elevations (Willow Creek, Kyle Canyon Campground). The flight period extends from early March through early December in 3 or more broods.

SPECIMENS EXAMINED: (109) Many records for Las Vegas and Moapa valleys with extreme dates from 3 Mar. (75, Las Vegas, NSM) to 1 Dec. (77, Tule Springs, s). High elevation records are for WC, 22 June 68 (JFL) and KC Campground, 25 July 77 (1 f).

ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Medicago sativa (Fabaceae); Helianthus annuus, Bebbia juncea, Baileya multiradiata, Solidago spectabilis, Tetradymia axillaris, Stephanomeria sp. (Asteraceae).

Pholisora libya libya (Scudder).

Uncommon and very local in (some) stands of *Atriplex canescens* in Las Vegas and Moapa valleys. It flies in two broods from mid April to late June and early September to mid October. The only record away from the valley floors is for Kyle Canyon at 6800' at an unusual date of 27 July.

Specimens from Moapa Valley are typical of the nominate subspecies; certain specimens from the Las Vegas Valley (Corn Creek) have reduced maculation on the ventral hindwing thus showing intermediacy towards *P. libya lena* (Edwards) of the Great Basin.

10 J. Res. Lepid.

SPECIMENS EXAMINED: (57) Hidden Valley, 4 May 77 (1 m); 1 mi. E. OV, 4 May 77 (4 m); Bowman's Reservoir, 4 May 77 (1 m, 4 f), 7 May 78 (1 f, CSL), 17 May 78 (1 m, 1 f, NSM; 1 m, 1 f, CSL; 5 m, 2 f), 7 June 77 (1 f), 15 June 77 (2 m, 1 f), 17 Sept. 77 (1 f), 27 Sept. 78 (2 m); LO, 7 June 77 (1 f), 16 June 77 (2 m, 1 f, CSL; 2 m, 1 f), 16 Oct. 77 (1 f); Las Vegas, 18 June 68 (1 f, UNLV); CN, 22 June 68 (1 m, 2 f), 3 Sept. 75 (2 m, 2 f, NSM), 15 Sept. 64 (4 m, 2 f, NSM), 15 Sept. 66 (1 m, NSM), 7 Oct. 77 (1 m); MF, 25 June 77 (1 m); KC at Deer Creek Rd., 27 July 61 (1 m); Clark Co., 17 Sept. 73 (1 m, UNLV); Tule Springs, 25 Sept. 62 (1 m).

ADDITIONAL RECORDS: Bowman's Reservoir, 13 Apr. 78, 29 Sept. 77 (s); PV, 24 Apr. 78, 10 May 77 (s); CN, 22 June 68, 29 June 72 (JFL), 29 June 63, 1 Sept. 63 (KR), 25 Sept. 64 (PJH); Las Vegas, 10 Sept. 75 (s), 6 Oct. 62 (JFL); OV, 17 Sept. 77 (s).

ADULT RESOURCES: Heliotropium curassavicum (Boraginaceae); Prosopis glandulosa, Medicago sativa (Fabaceae); Baileya pleniradiata, Baccharis sp., Pluchea sericea (Asteraceae).

### Pholisora gracielae MacNeill.

Locally common to abundant in Moapa Valley but only in close association with Atriplex lentiformis. We have not found this species in stands of this plant in the Las Vegas Valley or in the Colorado River Valley south of Davis Dam. Its flight period began sometime before 17 April and continued in 3 nearly non-overlapping broods through 29 September during 1977. Approximately equal peaks in numbers were at 2 month intervals on 4 May, 4 July and 4 September with numbers sharply lower 1-2 weeks on either side of the peaks. California populations were reported to have but 2 broods (MacNeill 1970, Emmel and Emmel 1973). The first brood has well developed subapical spots on the forewing; the second and third broods have these spots much reduced or wanting.

SPECIMENS EXAMINED: (122) Hidden Valley, 13 Apr. 78 (1 m, CSL), 17 Apr. 77 (17 m, 3 f), 4 May 77 (15 m, 7 f), 7 May 78 (1 f, CSL; 1 m, 1 f, NSM), 15 May 77 (5 m), 7 June 77 (1 m), 15 June 77 (3 m, 2 f), 27 June 77 (6 m), 4 July 77 (20 m, 7 f), 9 Aug. 77 (1 f), 4 Sept. 77 (7 m, 1 f), 17 Sept. 77 (1 m); Bowman's Reservoir, 4 May 77 (2 m, 1 f), 4 July 77 (2 m), 29 Sept. 77 (1 m); LO, 15 June 77 (1 f), 16 June 77 (2 f, CSL), 17 June 77 (1 f, NSM), 27 June 77 (1 f), 10 July 68 (1 m, 1 f), 12 July 77 (2 m, 1 f), 23 Aug. 77 (3 m, 1 f), 4 Sept. 66 (2 f).

ADDITIONAL RECORDS: Bowman's Reservoir, 27 June 77, 12 July 77, 23 Aug. 77, 4 Sept. 77 (s); LO, 4 July 77 (s); Hidden Valley, 12 July 77, 30 July 77, 23 Aug. 77 (s).

LARVAL FOODPLANTS: Atriplex lentiformis (Torr.) Wats. (Chenopodaceae); Moapa Valley (adult assoc.).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Heliotropium curassavicum (Boraginaceae); Medicago sativa (Fabaceae).

Pholisora alpheus oricus Edwards.

Locally common, especially along desert washes, above the valley floors. The single brood flies from mid March to late May. It is invariably found in association with Atriplex canescens.

SPECIMENS EXAMINED: (57) Ash Springs, 19 Mar. 72 (1 m); KC, 6-17 mi. W. U.S. 95, 4 Apr. 77 (1 m), 10 Apr. 78 (2 m), 11 Apr. 78 (1 m), 17 Apr. 66 (1 m), 18 Apr. 77 (2 m, 1 f), 18 Apr. 78 (2 m), 19 Apr. 78 (5 m, 1 f), 26 Apr. 77 (1 m) 26 Apr. 78 (3 m, 1 f), 30 Apr. 78 (5 m), 1 May 67 (1 m, NSM), 1 May 77 (2 m, 2 f), 2 May 78 (1 m),

11 May 78 (1 m), 13 May 78 (1 m); 0.5 mi. W. Blue Diamond, 20 Apr. 77 (1 f); 0.5 mi. S. Red Springs, 21 Apr. 79 (3 m, 1 f), 29 Apr. 79 (2 m, 3 f); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 22 Apr. 78 (4 m), 11 May 78 (1 m, 1 f); LC, 23 Apr. 66 (1 m); WC, 27 Apr. 77 (2 m), 29 Apr. 77 (2 m, 1 f).

ADDITIONAL RECORDS: 9 mi. W. Davis Dam, 23 Mar. 78 (s); Davis Dam, 31 Mar. 62 (R. C. Bechtal, *fide* OS); KC, 5000', 3-4 May 75 (1975 summ.); Cold Creek Ranger Station, 8 May 78 (s); KC, 17.1 mi. W. U.S. 95, 28 May 77 (s).

ADULT RESOURCES: Baileya multiradiata, Accamptopappus shockleyi, Taraxacum officinale (Asteraceae).

Heliopetes domicella domicella (Erichson).

The single record from the Newberry Mountains is the only one for the state. The closest known collection site is located near Parker Dam, San Bernadino Co., Çalifornia (Emmel and Emmel 1973), about 70 mi. to the south.

SPECIMENS EXAMINED: (1) GC, 12 Oct. 77 (1 m).

ADDITIONAL RECORDS: None.

Heliopetes ericetorum (Boisduval).

Common, usually near water, at elevations to 8500'; less common along desert washes and other areas away from water. The species is at least double brooded at high elevations and probably multivoltine at some low elevation sites. It flies at low elevations from late March to early November with very few July and August records and at high elevations from early May to late October with very few records from early August to mid September.

SPECIMENS EXAMINED: (128) The species is found nearly throughout the county except in the lower desert away from washes or roadsides. Extreme flight dates are from 21 Mar. (78, Las Vegas, 1 f, CSL) to 4 Nov. (77, Las Vegas, 1 m, UNLV).

LARVAL FOODPLANTS: Sphaeralcea ambigua Gray (Malvaceae): Lovell Wash, 8.9 mi. W. Pahrump Rd., 22 June 77 (ovip.). Sphaeralcea grossulariaefolia (Hook. & Arn.) Rydb. var. pedata (Torr.) Kearney (Malvaceae): 1 mi. W. WC, 25 May 78 (ovip. lower leaf surface, 12:15 PST).

ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Stanleya elata, Erysimum asperum (Brassicaceae); Eriogonum fasciculatum, Eriogonum heermannii (Polygonaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Verbena gooddingii (Verbenaceae); Monardella sp. (Lamiaceae); Acacia greggii, Melilotus albus, Medicago sativa (Fabaceae); Sambucus caerulea (Caprifoliaceae); Viguiera deltoidea, Bebbia juncea, Baileya multiradiata, Chaenactis sp., Senecio douglasii, Senecio multilobatus, Tetradymia axillaris, Cirsium sp., Pluchea sericea (Asteraceae); males frequently visit water.

Pyrgus scriptura (Boisduval).

Uncommon but widespread mainly along desert washes but also as high as 11,000'. This is a greater elevational range than reported previously (Scott 1975, MacNeill in Howe 1975). The flight period extends from late March to mid November. Most records are for April to June and September (no August records) indicating at least 2 broods. Spring and fall records are largely at lower elevations; June records are mainly at high elevations.

SPECIMENS EXAMINED: (46) 6 mi. N. Apex, 28 Mar. 71 (2 m, 3 f, NSM); CP to Pahrump Rd., 29 Mar. 78 (1 m), 22 Apr. 78 (3 m), 3 May 78 (1 m, CSL), 6 May 78 (1 m, CSL), 11 May 78 (1 m), 28 May 78 (3 m); 2 mi. E. Searchlight, 12 Apr. 69 (1 m,

NSM); 1 mi. N. Dry Lake on I-15, 19 Apr. 75 (1 m); WC, 23 Apr. 78 (2 m), 27 Apr. 77 (2 m), 29 Apr. 77 (1 f, NSM; 2 m, CSL), 6 June 78 (1 m); KC, 9-15 mi. W. U.S. 95, 1 May 77 (1 m), 6 June 78 (1 m), 23 June 77 (1 f), 28 Sept. 77 (1 m); Nipton Pass, 4 May 78 (1 m); WC, 6 June 78 (2 m, 1 f), 15 June 78 (1 m), 22 June 68 (1 f), 22 June 78 (1 m), 23 June 62 (1 m), 20 July 78 (1 m); LC, 8200′, 10 June 62 (1 m, 1 f); Lovell Wash, 4500′, 17 June 62 (1 m); KC, 6.6 mi. W., 0.9 mi. N. U.S. 95, 21 June 78 (1 m), Las Vegas, 22 June 66 (1 f); Hidden Valley, 12 July 77 (1 m); LO, 28 Sept. 67 (1 m, NSM); Clark Co., 28 Oct. 70 (1 f, UNLV).

ADDITIONAL RECORDS: LC, 0.5-3 mi. W. U.S. 95, 7 Apr. 71 (REW); Potosi Mt. Rd., 8 Apr. 71 (REW); U.S. 93, 5 mi. N. I-15, 17 Apr. 77 (s); U.S. 95, 5 mi. N. KC, 23 Apr. 78 (s); CP to Pahrump Rd., 2 May 78 (s); 1 mi. W. WC, 8 May 78 (s); Hidden Valley, 15 May 77 (s); WC, 6 June 78 (s); Trout Canyon, 14 June 77 (s); LC ballfield, 23 June 77 (s); Mt. Charleston, 11,000', 24 June 68 (JFE, OS); MS, 30 June 63 (KR); Las Vegas, 9-10 Sept. 62 (JFL); Moapa Valley, 21 Oct. 67 (JL); 11 mi. W. Searchlight, 11 Nov. 75 (CDM).

ADULT RESOURCES: Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Baileya multiradiata, Tetradymia canescens, Taraxacum officinale (Asteraceae).

Pyrgus communis (Grote).

Common to abundant in many habitats throughout the county to the top of Charleston Peak. At low elevations, the flight period extends from early February to mid December and at high elevations from early May to mid November.

SPECIMENS EXAMINED: (431) Records from a large number of locations with extreme dates of 4 Feb. (77, Boulder City, s) to 17 Dec. (70, Calico Basin, 1 f, UNLV).

LARVAL FOODPLANTS: Sphaeralcea ambigua Gray (Malvaceae): CP, 1.5 mi. S. Pahrump Rd., 22 Apr. 78 (ovip., lower leaf surface of lower leaves, 12:30 PST).

ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Smilacina stellata (Liliaceae); Tamarix pentandra (Tamariacaceae); Descuriana pinnata (Brassicaceae); Eriogonum fasciculatum, Eriogonum wrightii, Eriogonum heermannii, Eriogonum sp. (Polygonaceae); Allionia incarnata (Nyctagnaceae); Apocynum androsaemifolium (Apocynaceae); Sarcostemma hirtellum (Asclepiadaceae); Langlosia setosissima (Polemoniaceae); Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum, Crypatantha sp. (Boraginaceae); Physalis crassifolia (Solanaceae); Monardella sp. (Lamiaceae); Medicago sativa, Trifolium repens (Fabaceae); Viguiera multifolora, Helianthus annuus, Bebbia juncea, Baileya multiradiata, Baileya pleniradiata, Chaenactis fremontii, Pectis papposa, Acamptopappus shockleyi, Chrysothamnus sp., Erigeron sp., Senecio douglasii, Tetradymia canescens, Cirsium sp., Taraxacum officinale (Asteraceae).

Erynnis brizo burgessi (Skinner).

Locally common in the vicinity of oaks from 4000' to 7000'. The single brood flies from late March to mid June.

SPECIMENS EXAMINED: (94) Willow Springs, 23 Mar. 77 (2 m, NSM); Lost Creek, 23 Mar. 77 (1 m, NSM), 29 Mar. 78 (1 f, CSL), 20 Apr. 77 (2 m); CC, 29 Mar. 71 (2 m, 1 f, NSM), 8 Apr. 79 (6 m), 13 Apr. 78 (1 m, NSM; 2 m), 14 Apr. 77 (5 m, 3 f, NSM), 27 Apr. 78 (1 m, 1 f, NSM; 2 m), 10 May 78 (4 m, 1 f), 12 May 77 (1 m, CSL); Icebox Canyon, 21 Apr. 77 (1 f, NSM); White Rock Springs, 21 Apr. 79 (1 m); XM, 22 Apr. 79 (1 m); WC, 27 Apr. 77 (12 m, 2 f), 8 May 78 (4 m), 25 May 78 (3 m), 5 June

79 (3 m); WC, 27 Apr. 77 (1 m, NSM; 1 m, 2 f, CSL), 29 Apr. 77 (1 m, NSM), 8 May 78 (1 m), 25 May 78 (2 m), 30 May 66 (1 f), 13 June 77 (2 m, 1 f); Seep Canyon, 28 Apr. 73 (4 m, 1 f, NSM); 1 mi.W. RD Summit, 28 Apr. 77 (1 f, NSM); Pine Creek, 28 Apr. 75 (1 m, NSM); KC, 1 May 71 (1 m, 1 f); KC, 20 mi. W. U.S. 95, 2 May 77 (1 m, 1 f); Charleston Mts., 12-14 May 34 (6 m, 1 f, LACM); 0.5 mi. E. MS, 13 May 79 (1 m).

ADDITIONAL RECORDS: CC, 8 Apr. 77 (RB), 18 May 78 (s); Pine Creek, 2 May 77 (s); Oak Creek Canyon, 11 May 78 (s); KC Ski Run, 13 May 78 (s); LC, 29 May 50 (LACM); KC Campground, 31 May 77 (s); WC, 6 June 78 (s), 11 June 79, 13 June 77 (s).

LARVAL FOODPLANTS: Quercus gambelii Nutt. (Fagaceae): WC, 27 Apr. 77 (ovip. leaf buds). Quercus turbinella Greene (Fagaceae): CC, 10 May 78 (ovip. at base of leaf).

ADULT RESOURCES: Erodium cicutarium (Geraniaceae); Eriodictyon angustifolium (Hydrophyllaceae); Ribes aureum (Saxifragaceae); adults often visit water. Erynnis funeralis (Scudder & Burgess).

Uncommon and local especially in desert canyons at elevations below 4400'. The flight period consists of a relatively large spring brood (mid March to early June), a small summer brood (late June to late July) and a small fall brood (late August to late October). The summer and fall broods may not occur in every year and possibly depend on summer rainfall.

SPECIMENS EXAMINED: (33) 9 mi. W. Davis Dam, 17 Mar. 77 (1, NSM; 1 f, CSL), 31 Mar. 77 (1 m, 2 f, NSM; 1 m, CSL), 8 Apr. 77 (1 m); Newberry Mts., 23 Mar. 67 (1 m, ex UNLV); GC, 8 Apr. 77 (1 m, NSM; 1 m), 20 Apr. 78 (1 f), 5 May 77 (1 m, CSL; 1 m), 3 July 78 (1 f), 21 July 78 (2 m), 13 Sept. 78 (1 f), 27 Sept. 77 (1 m), 12 Oct. 77 (1 m); XM, 12 Apr. 78 (1 m), 20 Apr. 78 (1 f), 5 May 77 (1m), 23 May 78 (1 f), 20 Sept. 78 (1 m); Nelson, 19 Apr. 64 (1 m, 1 f); CC, 18 May 78 (1 m, CSL), 26 June 78 (2 m); Las Vegas, 27 June 68 (1 m); WC, 20 July 78 (1 m); CN, 10 Sept. 78 (1 f, CSL); LO, 23 Oct. 77 (1 f).

ADDITIONAL RECORDS: RD, 19 Mar. 72 (s); XM, 25 Mar. 79, 15 Apr. 78, 21 July 78, 27 Sept. 77 (s); PV, 4 Apr. 77 (s); GC, 12 Apr. 78, 15 Apr. 78, 12 May 78, 1 June 78, 21 Aug. 78, 20 Sept. 78, 26 Sept. 78, 4 Oct. 77 (s); Sacatone Wash, 15 Apr. 78, 20 Sept. 78 (s); 9 mi. W. Davis Dam, 15 Apr. 78 (s); CP Rd., 0.6 mi. S. Pahrump Rd., 22 Apr. 78 (s); CC, 10 May 78, 17-18 May 78, 20 May 78, 7 June 78 (s); Oak Creek Canyon, 11 May 78 (s); Willow Springs, 19 Sept. 78 (s); Pine Creek, 22 Sept. 78 (s).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Amsinckia tessellata (Boraginaceae); Viguiera deltoidea, Bebbia juncea, Chrysothamnus sp., Senecio douglasii, Tetradymia axillaris, Tetradymia canescens (Asteraceae).

Erynnis meridianus meridianus Bell.

Locally common in association with oaks above 3000'. It flies from mid March to early August with two September records. The number of broods apparently varies with location with possibly 3 at the lower elevations and usually one at higher elevations. We see no great differences in phenotype between early and late individuals although the earliest spring specimens tend to be smaller than later specimens.

SPECIMENS EXAMINED: (143) Numerous records from nearly throughout the Spring Range in the vicinity of oaks from 19 Mar. (72, Ash Spring, 1 m, 2 f) to 19 Sept. (78, Pine Creek, 2 m). Most specimens are from June. There are several

records for the Virgin Mts. and one for GC on 13 Sept. 78 (1 m, CSL; 1 f).

ADULT RESOURCES: Ranunculus cymbalaria (Ranunculaceae); Rorippa nasturtium-aquaticum, Erysimum asperum (Brassicaceae); Eriodictyon angustifolium (Hydrophyllaceae); Ribes cereum, Ribes aureum (Saxifragaceae); Cercis occidentalis, Melilotus albus (Fabaceae); Viguiera multiflora, Solidago spectabilis, Erigeron sp., Senecio douglasii, Senecio multilobatus, Cirsium sp., Taraxacum officinale (Asteraceae).

Erynnis telemachus Burns.

This species is known at present only from the Virgin Mountains flying in a single brood in May and early June.

SPECIMENS EXAMINED: (29) CC, 10 May 78 (2 m; 2 m, CSL), 18 May 78 (1 m; 1 m, CSL), 20 May 78 (1 m), 20 May 79 (12 m, 1 f), 29 May 78 (4 m), 7 June 78 (1 m), 8 June 78 (1 m, CSL); Virgin Mts., 30 May 74 (3 m, NSM).

ADDITIONAL RECORDS: None.

Chiomara asychis georgina (Reakirt).

The only record is a stray at Corn Creek.

SPECIMENS EXAMINED: (1) CN, 26 Sept. 65 (1 m, NSM).

ADDITIONAL RECORDS: None.

Systasea zampa (Edwards).

A small population occurs in the southern portion of the county in the Newberry Mountains. There are no other Nevada records.

SPECIMENS EXAMINED: (8) GC, 15 Apr. 78 (1 m), 20 Apr. 78 (1 m, CSL), 21 July 78 (1 m); 9 mi. W. Davis Dam, 20 Apr. 78 (1 m), 26 Sept. 78 (1 m, NSM); XM, 23 May 78 (1 m), 21 July 78 (1 m); Sacatone Wash, 20 Sept. 78 (1, CSL).

ADDITIONAL RECORDS: 9 mi. W. Davis Dam, 3 May 78 (s).

ADULT RESOURCES: Monardella sp. (Lamiaceae); Bebbia juncea (Asteraceae).

Thorybes pylades (Scudder).

This skipper is known for Clark County from 2 records from the Spring Range. SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: KC, 29 June 63 (KR); Pine Creek, 30 June 63 (KR).

Polygonus leo arizonensis (Skinner).

Three fall records are the only occurrences of this stray in Nevada.

SPECIMENS EXAMINED: (2) 10 mi. W. of Searchlight, 21 Sept. 72 (2 m, NSM).

ADDITIONAL RECORDS: GC, 13 Sept. 78 (s); LO, 9 Oct. 77 (s).

ADULT RESOURCES: Bebbia juncea (Asteraceae).

Epargyreus clarus huachuca (Dixon).

The only state specimens are from the Virgin Mountains where they associate with *Robinia neomexicana* from mid May to late June. Individuals of this population average smaller but are otherwise quite indistinguishable from southern Arizona *huachuca*.

SPECIMENS EXAMINED: (14) CC, 20 May 79 (1 m), 29 May 78 (1 m), 7 June 78 (1 m), 26 June 78 (6 m); Virgin Mts., 30 May 74 (5 m, NSM).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Robinia neomexicana (Fabaceae); males visit water.

### Family Papilionidae

Battus philenor philenor (Linnaeus).

There are several records of this species from April to October mostly in the low valleys. Specimens are generally quite worn. It is most likely non-resident but occurring as a stray from Arizona.

SPECIMENS EXAMINED: (4) CN, 18 July 65 (1 m); Las Vegas, 7 Sept. 68 (1 f); Stewart Springs, 29 Sept. 66 (2 m, NSM).

ADDITIONAL RECORDS: PV, 24 Apr. 78 (s); GC, 5 May 77, 21 Aug. 78 (s); Las Vegas, 14 June 77, 26 June 77, 23 Aug. 66 (s); KC Ski Run, 25 July 77 (s); CN, 31 July 65 (RES); KC, 7600', 5 Aug. 72 (JFL); Roger's Spring, 10 Oct. 64 (PJH). ADULT RESOURCES: Cirsium sp. (Asteraceae).

Papilio bairdii bairdii Edwards.

Rare in the Spring Range; the 4 known specimens are probably from Kyle Canyon where its probable foodplant (*Artemesia dracunculus*) is common. All records are in mid June.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: (all *fide JFE*) Mt. Charleston, 11-12 June 35 (2 f, Rudkin colln.), 15 June 40 (1 m, Calif. Acad. Sci.), KC, no date (T. Davies colln.). *Papilio rudkini* Comstock.

Locally common in the upper desert and occasional elsewhere in towns, cultivated areas and once to 9000'. There are two main broods in March and April and in September and October with scattered individuals at other times of the year (records from mid February to late November). The fall brood may be quite small or lacking, depending on summer rainfall. The dark form "clarki" comprises about 14% of the local population (approximate estimate, no statistical data available).

SPECIMENS EXAMINED: (311 including 45 "clarki") Records extend from 12 Feb. (77, KC, 1 mi. W. U.S. 95, 1 m) to 21 Nov. (77, Las Vegas, 1 m, UNLV). There are very few records (12 specimens) from June through August.

LARVAL FOODPLANTS: Thamnosma montana Torr. & Frem. (Rutaceae): CC, 27 Apr. 78 (mature larva, dark form, emerged as form "clarki", CSL); CP Rd., 1.5 mi. S. Pahrump Rd., 11 May 78 (ovip. upper leaf surface, 10:00 PST); CC, 20 May 79 (mature larva); RC, 27 May 78 (ovip. on stem at leaf base, 11:00 PST); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 28 May 78 (ovip. on stem at leaf base, 09:45 PST, 11:20 PST); Pahrump Rd., 3 mi. W. Blue Diamond turnoff, 26 Sept. 77 (ovip. on stem, 09:15 PST, 09:30 PST).

ADULT RESOURCES: Delphinium parishii (Ranunculaceae); Dichlostemma pulchellum (Amaryllidaceae); Arabis sp. (Brassicaceae); Eriogonum plumatella (Polygonaceae); Asclepias subulata (Asclepiadaceae); Phacelia vallis-mortae, Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum, Amsinckia tessellata, (Boraginaceae); Penstamon palmeri (Scrophulariaceae); Verbena gooddingii (Verbenaceae); Salazaria mexicana, Salvia dorrii (Lamiaceae); Ribes cereum (Saxifragaceae); Rosa woodsii (Rosaceae); Acacia greggii, Medicago sativa, Melilotus albus, Lotus rigidus, Astragalus lentiginosus (Fabaceae); Thamnosma montana (Rutaceae); Encelia farinosa, Encelia virginensis, Bebbia juncea, Haplopappus sp., Chrysothamnus sp., Senecio douglasii, Cirsium sp., Stephanomeria sp., Taraxacum officinale (Asteraceae).

Papilio indra martini Emmel & Emmel.

Locally common in the Spring Range where there are two broods from mid March to late April and late June to mid July. The Spring Range population varies from individuals with wide postmedian bands resembling  $P.\ i.$  nevadensis Emmel & Emmel to those with a near absence of the postmedian band in the hindwing as is typical of martini (see also Emmel & Emmel 1974). There are additional populations of indra known from the Newberry, Mormon and Virgin mountains which differ from these. The records (1963 summ.) of P. indra near fordi Comstock & Martin refer to the Spring Range population. Tyler's (1975) inclusion of fordi in Nevada is also in error.

SPECIMENS EXAMINED: (6) Ash Springs, 30 June 69 (2 m, 1 f, LACM), 6 July 62 (3 m).

ADDITIONAL RECORDS: Calico Basin, 19 Mar. 62 (JFL); Willow Spring, 19 Apr. 66 (JFL), 17 June 78 (DM); White Rock Springs, 19 Apr. 75 (JB); 21 Apr. 79 (s), 2.1 mi. E. Lovell Wash, RD Summit Rd., 24 Apr. 77 (s); Ash Springs, 25 June 68 (JFE, OS); north of Deer Creek Campground, 29 June 63 (KR); Lovell Canyon, 10 July 75 (CSL).

LARVAL FOODPLANTS: Lomatium parryi (Wats.) Macbr. (Apiaceae): Calico Basin, 28 Mar. 72 (larvae, JFL); Ash Spring, 25 June 68 (larvae, JFE, OS).

ADULT RESOURCES: Lomatium parryi (Apiaceae); Cirsium sp. (Asteraceae).

Papilio rutulus rutulus Lucas.

Fairly common is the Spring Range from 6000' to 9000' especially in Kyle Canyon. It flies from late May to early August in a single brood.

SPECIMENS EXAMINED: (58) KC, 20 mi. W. U.S. 95, 31 May 77 (1 m), 14 June 77 (1 m), 28 June 77 (1 m), 28 June 78 (1 f), 5 July 78 (1 m); above Cathedral Rock Campground, 17 June 77 (1 m, 1 f); KC Ski Run, 17 June 77 (1 m, NSM); 20 June 79 (1 m, 1 f), 22 June 78 (1 f), 26 June 79 (2 m, 2 f), 2 July 78 (2 m), 5 July 77 (1 f), 7 July 77 (2 m, CSL), 10 July 75 (2 m), 18 July 79 (1 m); KC Campground, 20 June 79 (1 m), 24 June 79 (2 m), 26 June 79 (2 m), 7 July 77 (1 m); KC, 7650', 27 June 65 (1 f); Charleston Park, 30 June 77 (3 m, CSL; 2 m, 2 f, NSM); Little Falls, 5 July 65 (6 m, 3 f), 13 July 65 (2 m, 1 f), 20 July 65 (1 m); KC, 6050', 5 July 65 (1 m); end KC, 13 July 65 (1 m); KC, 7500', 15 July 74 (2 m, 2 f); Rainbow Canyon, 20 July 65 (1 f); KC, 9000', 25 July 65 (1 f).

ADDITIONAL RECORDS: Numerous records for KC, earliest on 29 May 63 (JFL); latest on 1 Aug. 67 (s). One record for west slope in Lovell Wash at Spring Mountain Youth Camp on 22 June 77 (s).

LARVAL FOODPLANTS: Populus tremuloides Michx. (Salicaceae): KC Ski Run, 26 June 79 (ovip. lower surface of leaf near midrib, 10:00 PST); 5 July 77 (ovip.); 10 July 79 (ovip. upper leaf surface, 08:50 PST).

ADULT RESOURCES: Ipomopsis aggregata (Polemoniaceae); Penstamon utahensis (Scrophulariaceae); Erysimum asperum (Brassicaceae); Cirsium sp., Taraxacum officinale (Asteraceae); visit water on occasion.

Papilio multicaudatus Kirby.

The only known colony of this species in Clark County is in the Virgin Mountains. Specimens have wide dark borders similar to Arizona material.

SPECIMENS EXAMINED: (18) CC, 27 Apr. 78 (1 m, CSL), 17-18 May 78 (2 m, 1 f; 2 m, CSL; 2 m, NSM), 20 May 79 (3 m), 29 May 78 (2 m, 2 f), 7-8 June 78 (2 m; 1 f, CSL).

ADDITIONAL RECORDS: CC, 10 May 78, 20 May 78, 26 June 78 (s). ADULT RESOURCES: Males occasionally visit water.

### **Family Pieridae**

Neophasia menapia (Felder & Felder).

Rare but apparently not uncommon in some years in the Spring Range above 7400'. The few records indicate a single brood flying from late July to late August. SPECIMENS EXAMINED: (1) KC Ski Run, 1 Aug. 77 (1 m).

ADDITIONAL RECORDS: KC, 7400', 29 July 62 (JFL), 31 Aug. 62 (JFL); Charleston Mts., 6 Aug. 61 (RES); KC, 7800', 8 Aug. 62 (JFL), 12 Aug. 63 (JFL), 18 Aug. 63 (JFL); KC, 8 Aug. 74 (JAS).

ADULT RESOURCES: Argemone minita (Papaveraceae).

Pieris beckerii beckerii Edwards.

Uncommon, but sometimes common, usually at elevations between 2900' and 7200'. Its flight period is from late March to mid November. At least 4 broods appear to be involved in some years along some upper desert washes; single broods may be raised in other areas. Summer rainfall may be regulatory as suggested by Emmel and Emmel (1973).

SPECIMENS EXAMINED: (121) Numerous records for many locations at middle elevations in much of the county with dates between 3 Mar. (78, KC, 6.6 mi. W., 0.9 mi. N. U.S. 95, 1) and 13 Nov. (77, KC, 9.3 mi. W. U.S. 95, 1 m). The species is most common in the Spring Range and rare in the Newberry and Virgin mountains. A few records also exist for the Las Vegas and Moapa valleys.

LARVAL FOODPLANTS: Stanleya pinnata (Pursh) Britton (Brassicaceae): CP Rd., 1.8 mi. S. Pahrump Rd., 29 Apr. 78 (ovip. main stem, 1/2 way up at leaf base, 11:15 PST); 1 mi. W. WC, 8 May 78 (ovip. at apex of flower bud, 11:30 PST); Trout Canyon Rd., 0.8 mi. W. Spring Mt. Youth Camp, 14 June 77 (ovip. lower leaf surface); KC, 15 mi. W. U.S. 95, 23 June 77 (ovip.). Stanleya elata Jones (Brassicaceae): KC, 9.3 mi. W. U.S. 95, 1 May 77 (ovip. on main stem).

ADULT RESOURCES: Clematis ligusticifolià (Ranunculaceae); Stanleya pinnata, Arabis sp. (Brassicaceae); Eriogonum fasciculatum, Eriogonum microthecum (Polygonaceae); Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare, Salvia dorrii (Lamiaceae); Astragalus lentiginosus (Fabaceae); Teradymia canescens (Asteraceae).

Pieris sisymbrii elivata (Barnes & Benjamin).

Uncommon, especially at middle elevations between 4000' and 6500', in most of the county. The single brood flies from mid March to mid May with a single record in mid June. All southern Nevada females examined were at least slightly tinged with yellowish.

SPECIMENS EXAMINED: (100) Records extend from 18 Mar. (72, XM, JFL) to 17 May (78, CC, s). One record on 14 June 77 (KC, 17.1 mi. W. U.S. 95, s). ADULT RESOURCES: *Arabis* sp. (Brassicaceae).

Pieris protodice protodice Boisduval & LeConte.

Common to abundant at low elevations and less common at the higher elevations to at least 10,000'. The flight period extends throughout the year. Fresh individuals are found on warm days in midwinter.

The small spring form "vernalis" flies at low elevations from January to April and apparent intermediates with the typical form occurring into May. Specimens from

18 J. Res. Lepid.

October to December are large but more heavily marked below than the summer form.

SPECIMENS EXAMINED: (391) Specimens are from many localities throughout the county except the highest elevations.

LARVAL FOODPLANTS: Lepidium lasiocarpum Nutt. (Brassicaceae): CP Rd., 1.5 mi. S. Pahrump Rd., 29 Apr. 78 (ovip., upper leaf surface, 09:30 PST). Descurainia pinnata (Walt.) Britt. ssp. glabra (Woot. & Standl.) Detl. (Brassicaceae): U.S. 93, 13 mi. N. I-15, 14 May 78 (ovip., 09:15 PST). Descurainia pinnata (Walt) Britt. ssp. halictorum (Ckll.) Delt. (Brassicaceae): WC, 8 May 78 (ovip. 2x, lower leaf surface of upper leaves, 13:30 PST).

ADULT RESOURCES: Sphaeralcea grossulariaefolia (Malvaceae); Linum lewisii (Linaceae); Tamarix pentandra (Tamaricaceae); Stanleya pinnata, Sisymbrium altissimum (Brassicaceae); Eriogonum corymbosum, Eriogonum fasciculatum (Polygonaceae); Menodora spinescens (Oleaceae); Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Marrubium vulgare, Salvia dorrii (Lamiaceae); Fallugia paradoxa (Rosaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Medicago sativa, Melilotus albus, Melilotus officinalis, Astragalus lentiginosus (Fabaceae); Viguiera deltoidea, Viguiera multiflora, Helianthus annuus, Encelia virginensis, Bebbia juncea, Baileya multiradiata, Baileya pleniradiata, Chaenactis fremontii, Haplopappus sp., Chrysothamnus sp., Erigeron sp., Senecio douglasii, Senecio multilobatus, Pluchea sericea, Cirsium sp., Taraxacum officinale (Asteraceae).

Pieris rapae (Linnaeus).

Common in urban areas, less common in agricultural areas and small, recently established (since 1968) wild colonies at higher elevations at Willow and Cold creeks and in Kyle Canyon. A wild, possibly fugitive, colony was found in the upper desert near Cottonwood Pass in 1978. There are additional records near desert springs and in the Virgin and Newberry mountains. The flight period is from late January to mid December at low elevations and from late April to mid October at high elevations. There is only one record before 1961 (Las Vegas, 12 Apr. 60, PJH).

SPECIMENS EXAMINED: (104) Many records especially in Las Vegas Valley throughout most of the year.

LARVAL FOODPLANTS: Caulanthus cooperi (S. Wats.) Pays (Brassicaceae); CP Rd., 1.8 mi. S. Pahrump Rd., 29 Apr. 78 (ovip., 2x, lower leaf surface, just to one side of mid rib, 12:00 PST). Descurainia sophia (L.) Webb (Brassicaceae): MS, 11 May 78 (ovip., 3x, lower leaf surface, 12:30 PST). Rorippa nasturtium-aquaticum (L.) Schinz & Thell (Brassicaceae): WC, 1 July 77 (ovip. lower leaf surface). Brassica oleracea L. var. botrytis L. (Brassicaceae): Las Vegas (many records of ovip. and larvae). Brassica oleracea L. var. capitata L. (Brassicaceae): Las Vegas (many records of ovip. and larvae).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Sisymbrium altissimum, Rorippa nasturtium-aquaticum (Brassicaceae); Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Amsinckia tessellata (Boraginaceae); Medicago sativa, Melilotus albus, Astragalus sp. (Fabaceae); Chaenactis fremontii, Pluchea sericea, Taraxacum officinale (Asteraceae).

Colias eurytheme Boisduval.

Abundant in agricultural areas and occasional in the desert and near springs at low elevations and fairly common in open areas at high elevations. Low elevation records

extend from mid February to mid December and those at high elevations from late April to mid November. Desert records are for spring and fall.

Early spring (March, April) and late fall (October, November) specimens are smaller, paler and usually more heavily dusted with black and have more extensive pink markings beneath than summer specimens. This indicates that the form "ariadne" is a valid form in this area and is not a hybrid between this species and C. philodice Godart as sometimes suggested (Klots 1951, Brown, et al. 1957). Colias philodice is very rare in southern Nevada. The form "alba" comprises 31% of the local female population (approximate estimate, no statistical data available).

SPECIMENS EXAMINED: (615) A large number of records from numerous locations to 11,000' with records from 11 Feb. to 19 Dec. It probably can be found at sometime as either a resident or stray in all parts of the county.

LARVAL FOODPLANTS: Medicago sativa L. (Fabaceae); LO, 4 July 77 (ovip.). Trifolium repens L. (Fabaceae): WC, 8 May 78 (ovip., lower leaf surface, 12:20 PST).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Linum lewisii (Linaceae); Tamarix pentandra (Tamaricaceae); Argemone minita (Papaveraceae); Stanleya pinnata, Sisymbrium altissimum, Erysimum asperum (Brassicaceae); Eriogonum wrightii, Polygonum lapathifolium (Polygonaceae); Arctostaphylos pungens (Ericaceae); Convolvulus sp. (Convolvulaceae); Apogynum androsaemifolium (Apocynaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Lycium sp. (Solanaceae); Verbena gooddingii (Verbenaceae); Fallugia paradoxa, Rosa woodsii (Rosaceae); Lupinus sp. Medicago sativa, Melilotus albus, Melilotus officinalis, Robinia neomexicana (Fabaceae); Viguiera multiflora, Helianthus annuus, Bebbia juncea, Baileya multiradiata, Eriophyllum wallacei, Pectis papposa, Haplopappus sp., Chrysothamnus sp., Machaeranthera tortifolia, Baccharis sp., Senecio douglasii, Tetradymia canescens, Cirsium sp., Taraxacum officinale (Asteraceae).

Colias philodice philodice Godart.

A stray from Las Vegas is the only specimen from the county.

SPECIMENS EXAMINED: (1) Las Vegas, 20 Oct. 1974 (1 f, ex UNLV).

ADDITIONAL RECORDS: None.

Colias alexandra edwardsii Edwards.

A small colony of this species was discovered in the southern portion of the Spring Range in 1978. The only other record for the county is a fall record from Kyle Canyon.

SPECIMENS EXAMINED: (5) CPRd., 0.6-1.8 mi. S. Pahrump Rd., 22 Apr. 78 (1 m), 29 Apr. 78 (1 m), 6 May 78 (1 m, CSL), 11 May 78 (1 m, apparent hybrid x C. eurytheme or C. philodice); KC, 9.3 mi. W. U.S. 95, 15 Oct. 77 (1 f).

ADDITIONAL RECORDS: CP Rd., 0.6-1.5 mi. S. Pahrump Rd., 16 Apr. 79, 29 Apr. 79, 19 May 78 (s).

Colias cesonia (Stoll).

Usually rare at elevations to 7600' with records from mid February to mid November. In most years it may be a stray but it was common and produced at least two broods in the Newberry Mountains in 1978.

SPECIMENS EXAMINED: (47) GC, 15 Apr. 78 (1 f), 21 Apr. 78 (1 f, CSL), 3 May 78 (1 f), 23 May 78 (5 m, 1 f), 1 June 78 (8 m, NSM; 3 m, CSL); 3 July 78 (1 m, 2

f), 21 July 78 (2 m, 2 f), 4 Aug. 78 (2 m); CP Rd., 0.6-1.5 mi. S. Pahrump Rd., 16 Apr. 77 (1 f), 28 May 78 (1 m); Bowman's Reservoir, 7 May 78 (1 m, CSL); Bridge Canyon, 12 May 78 (1 f); XM, 1 June 78 (1 m, CSL), 21 July 78 (2 m); WC, 22 June 78 (2 m, CSL), 1 July 77 (1 m), 4 July 62 (1 m), 20 July 78 (2 m); WC, 4 July 62 (1 f), 20 July 78 (2 m); KC Ski Run, 23 July 78 (1 m), 25 July 78 (1 m, NSM).

ADDITIONAL RECORDS: GC, 20 Feb. 78, 20 Apr. 78, 12 May 78 (s); 1 mi. W. MS, 26 Mar. 68, 11 May 78 (s); Sacatone Wash, 15 Apr. 78 (s); PV, 19 Apr. 78, 28 Apr. 78 (s); 9 mi. W. Davis Dam, 20 Apr. 78 (s); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 22 Apr. 78, 11 May 78 (s); Hidden Valley, 27 Apr. 78 (s); Pine Creek, 2 May 77, 22 May 78 (s); Willow Springs, 2 May 78 (s); CC, 10 May 78, 29 May 78, 7 June 78 (s); LO, 17 May 78, 11 Nov. 77 (s); Bunkerville, 17 May 1978 (s); XM, 23 May 78, 3 July 78 (s); WC, 11 June 79 (s); Lovell Wash, 17 June 62, 18 July 62 (s); Charleston Park, 25 June 68 (JFE, OS); Ash Springs, 6 July 62 (s); Echo Canyon, 23 July 78 (s); KC Ski Run, 25 July 78 (s); Charleston Mts., 31 July 65 (JL, RES); WC, 30 Aug. 77 (s); Jean, 2 Sept. 78 (s); RR, 28 Oct. 77 (s).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Amsonia tomentosa (Apocynaceae); Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare, Monardella sp. (Lamiaceae); Bebbia juncea, Tetradymia canescens, Cirsium sp., (Asteraceae).

Phoebis sennae marcellina (Cramer).

Scattered records of strays are the only ones for the state. A relatively good flight was noted in the spring of 1978.

SPECIMENS EXAMINED: (5) Willow Spring, 10 May 66 (1, JFL); GC, 1 June 78 (1 m, CSL), 3 July 78 (1 f); OV, 10 July 68 (1, JFL); KC, 7400', 18 Aug. 63 (1, JFL).

ADDITIONAL RECORDS: PV, 10 Apr. 78, 24 Apr. 78, 19 May 79 (s); XM, 12 Apr. 78 (s); GC, 12 Apr. 78 (s); Hidden Valley, 13 Apr. 78 (CSL, s); CC, 13 Apr. 78 (s); WC, 22 June 78 (s).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Prosopis juliflora (Fabaceae).

Eurema mexicana (Boisduval).

Four specimens and a few sightings represent the only state records. This species may occasionally establish itself as a breeding insect in southern Nevada but this has yet to be shown.

SPECIMENS EXAMINED: (4) Willow Springs, 10 May 66 (3, JFL); 21 May 66 (1, JFL).

ADDITIONAL RECORDS: 9 mi. W. Davis Dam, 23 Mar. 78, 20 Apr. 78 (s); I-15, 2 mi. N. Dry Lake, 19 Apr. 75 (s).

Eurema nicippe (Cramer).

Common in a variety of habitats to 7600' but mostly below 4000' in desert washes and the vicinity of springs. Records extend from late January to mid December involving possibly 4 broads in some areas. Open desert records indicate that there are 2 usual broads, one in early spring and one in fall.

Specimens from April through September are mostly yellow beneath; those from February and October to December represent the reddish winter form.

SPECIMENS EXAMINED: (126) Numerous records from the lower canyons from 29 Jan. (78, Las Vegas, s) to 11 Dec. (77, GC, 1 m, 3 f). Less common at higher elevations from 10 Apr. (68, MS, s) to 16 Nov. (77, KC, 20 mi. W. U.S. 95, s).

LARVAL FOODPLANTS: Cassia armata Wats. (Fabaceae): 9 mi. W. Davis Dam, 3 May 78 (ovip., lower surface of flower bud, 09:00 PST).

ADULT RESOURCES: Sarcostemma hirtellum (Asclepiadaceae); Physalis crassifolia (Solanaceae); Monardella sp. (Lamiaceae); Medicago sativa, Melilotus albus (Fabaceae); Viguiera deltoidea, Helianthus annuus, Bebbia juncea, Senecio douglasii, Cirsium sp. (Asteraceae).

Nathalis iole Boisduval.

Common and widespread in many habitats to 9000'. Its flight period extends from early February to mid December at low elevations and from late April to late October above 6000'. At least 4 broads appear to be involved in some areas but possibly only 2 in low desert.

Very early spring (February) specimens represent the winter form. The lower surface of both sexes of this form is very heavily overscaled with black nearly obscuring the underlying paler scales. The females are pale yellow with a reduction of the black markings on the inner margin of the forewing and on the hindwing. The yellow hindwing of the winter form contrasting with orangish hindwings of the summer form indicates, perhaps, that southern Nevada material belongs to the central segregate of this species (see Clench 1976). The validity of these color forms is yet to be demonstrated.

SPECIMENS EXAMINED: (107) Records are for much of the county with the earliest on 6 Feb. (77, 0.5 mi. S.W. Laughlin, 1 m, 1 f) and latest on 12 Dec. (77, Tule Springs, s).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Eriogonum fascicu latum (Polygonaceae); Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Viguiera multiflora, Chaenactis fremontii, Senecio douglasii, Taraxacum officinale (Asteraceae).

Anthocaris pima Edwards.

Common in some years, rare or absent in others in desert below 5200'. The flight period extends from mid February to early May. There is one main brood and possibly a partial second brood.

SPECIMENS EXAMINED: (123) Numerous records at low elevations between 11 Feb. (75, U.S. 93, 8 mi. N. I-15, s) and 4 May (78, Nipton Pass area, 2).

ADULT RESOURCES: Descuriana pinnata (Brassicaceae); Phacelia fremontii (Hydrophyllaceae); Amsinckia tessellata, Cryptantha sp. (Boraginaceae).

Anthocaris sara thoosa Scudder.

Uncommon mostly between 4000' and 7000' but it occasionally occurs at lower elevations. The single brood flies from mid February to late May with a peak in late March and April.

The material from southern Clark County is identical with California populations. The ventral maculation of Virgin Mountains material tends to be heavier as is southern Utah material. We agree with Emmel & Emmel (1973) on the separation of thoosa from Arizona A. s. inghami Gunder especially on the basis, especially, of ventral coloration.

SPECIMENS EXAMINED: (160) Pine Creek, 19 Mar. 64 (1 m, 1 f), 23 Mar. 77 (1 m, NSM); KC, 17.1 mi. W. U. S. 95, 22 Mar. 77 (1 m), 11 Apr. 77 (1 f); XM, 23 Mar. 78 (2 m, NSM; 2 m, 1 f), 25 Mar. 79 (21 m, 15 f), 12 Apr. 78 (1 m); Wilson Pass, 25 Mar. 78 (1 f); CC, 29 Mar. 71 (1 m, 1 f, NSM), 8 Apr. 79 (14 m, 26 f), 13 Apr. 74 (1 f, NSM), 13 Apr. 78 (8 m, 3 f), 14 Apr. 74 (3 m, NSM), 19 Apr. 75 (2 f, NSM), 27 Apr.

78 (3 m, NSM; 4 m), 10 May 78 (1 m, 1 f, NSM; 1 m); Willow Springs, 29 Mar. 78 (1 m); 2 mi. N. RC, 5 Apr. 78 (1 m, NSM; 1 m), 11 Apr. 78 (1 m, NSM), 15 Apr. 79 (6 m, 1 f), 4 May 78 (1 m); Nipton Pass, 12 Apr. 69 (6 m, 5 f, NSM); Lost Creek, 20 Apr. 77 (1 m, NSM); Potosi Mt. Rd. at Pahrump Rd., 20 Apr. 77 (1 f); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 24 Apr. 77 (2 f), 28 Apr. 77 (1 m, 2 f); Lovell Wash, 6.8 mi. N. Pahrump Rd., 24 Apr. 77 (1 f); WC, 27 Apr. 77 (2 f), 25 May 78 (1 f); Seep Canyon, 28 Apr. 73 (2 f, NSM); 1 mi. W. RD Summit, 28 Apr. 77 (5 m, 1 f, NSM); Cold Creek, 8 May 78 (1 m).

ADDITIONAL RECORDS: Several records from middle elevations with the earliest record on 16 Feb. (77, Spring Mt. Ranch, s).

ADULT RESOURCES: Arctostaphylos pungens (Eriaceae); Phacelia fremontii (Hydrophyllaceae); Amsinckia tessellata (Boraginaceae).

Euchloe hyantis lotta (Beutenmueller).

Uncommon but widespread especially at middle elevations to about 6200'. It flies in one brood from early March to mid May.

SPECIMENS EXAMINED: (134) Numerous records, usually away from the valley floors from 5 Mar. (78, PV, 2 f) to 19 May (78, 0.5-1.5 mi. E. MS, 1 m).

ADULT RESOURCES: Phacelia fremontii (Hydrophyllaceae); Ribes cereum (Saxifragaceae); Rhus trilobata (Anacardiaceae); Baileya multiradiata, Taraxacum officinale (Asteraceae).

### Family Riodinidae

Apodemia mormo mormo (Felder & Felder).

Common and occasionally locally abundant, especially along roadsides and washes where *Eriogonum inflatum* is common, to 6200'. It flies in at least 4 broods from early February to mid November. It is most common and widespread in spring; summer and fall broods may reflect rainfall patterns and/or the availability of alternate foodplants.

The common phenotype is of the nominate race with little tendency towards true A. m. deserti Barnes & McDunnough although the latter name has been applied to southern Nevada material. This insect commonly associates with Eriogonum inflatum and E. fasciculatum. In fall, a larger and darker phenotype associated with Eriogonum microthecum occurs at higher elevations. This phenotype occurs similarly in the desert ranges of California (fide JFE). Whether this represents a distinct unnamed subspecies needs confirmation.

SPECIMENS EXAMINED: (388) Records for many localities throughout the county between 4 Feb. (77, Boulder City, AB) to 16. Nov. (77, 1.8 mi. E. Blue Diamond, 1 m). The large, dark phenotype is known from such locations as MS and WC between 6 Sept. (69, NSM) and 7 Oct. (77).

LARVAL FOODPLANTS: Eriogonum deflexum Torr. (Polygonaceae): 0.5 mi. E. Boulder City, 3 Oct. 77 (ovip. at base of flower). Eriogonum plumatella Dur. & Hilg. var. plumatella Dur. & Hilg. (Polygonaceae): 10 mi. W. Davis Dam, 3 Aug. 77 (larvae on flower head). Eriogonum inflatum Torr. & Frem. (Polygonaceae): Searchlight, 1 Oct. 68 (larvae, 1968 summ.). Adults also associated with Eriogonum fasciculatum (RR, GC), Eriogonum microthecum (MS, WC), Eriogonum wrightii (Pine Creek) and Eriogonum heermannii (2 mi. N.RC).

ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Eriogonum fascicu latum, Eriogonum heermannii, Eriogonum microthecum, Eriogonum plumatella, Eriogonum umbellatum, Eriogonum wrightii, Eriogonum sp. (Polygonaceae); Cryp-

tantha sp. (Boraginaceae); Bebbia juncea, Baileya multiradiata, Baileya pleniradiata, Chaenactis fremontii, Palafoxia linearis, Acamptopappus shockleyi, Solidago spectabilis, Chrysothamnus sp., Baccharis sp., Senecio douglasii, Tetradymia canescens, Stephanomeria sp. (Asteraceae).

Apodemia palmeri marginalis (Skinner).

Locally common in mesquite stands in the valleys. It flies from mid April to mid October with 3 or possibly 4 broods in favorable years.

Southern Nevada material agrees well with marginalis described from nearby southern California and is paler and has consistently complete orange borders in contrast to the darker, supposedly nominate race from southern Arizona, with its often incomplete orange borders. A review of the species seems in order as the species was described from just north of Clark County at St. George, Utah.

SPECIMENS EXAMINED: (236) Numerous records between 17 Apr. (77, Hidden Valley, s) and 13 Oct. (77, PV, 1 m).

LARVAL FOODPLANTS: Prosopis glandulosa Torr. (Fabaceae): PV, 31 July 77 (ovip.). Prosopis pubescens Benth. (Fabaceae): PV, 2 Aug. 77 (ovip.).

ADULT RESOURCES: Heliotropium curassavicum (Boraginaceae); Prosopis glandulosa, Prosopis pubescens (Fabaceae); Baccharis sp. (Asteraceae).

Calephelis nemesis californica McAlpine.

Rare in fall with all records except one (Virgin Mountains) from the Logandale area of Moapa Valley in association with *Baccharis*. There are no other records for the state.

SPECIMENS EXAMINED: (13) Bowman's Reservoir, 30 July 77 (1 m); LO, 4 Sept. 66 (1 m), 27 Sept. 78 (2 m), 16 Oct. 77 (3 m, 2 f), 28 Oct. 77 (3 m); Virgin Mts. 12 Sept. 74 (1 f, NSM).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Baccharis sp. (Asteraceae).

Calephelis wrighti (Holland).

Small numbers from the Newberry Mountains are the only Nevada records. They probably represent a small breeding colony as its known foodplant, *Bebbia juncea*, is common there.

SPECIMENS EXAMINED: (20) GC, 21 July 78 (1 m), 13 Sept. 78 (1 m; 1 m, CSL), 20 Sept. 78 (1 m, CSL), 26 Sept. 78 (2 m, 3 f, CSL; 1 m, 1 f), 29 Oct. 78 (6 m), 3 Nov. 77 (1 m); Sacatone Wash, 20 Sept. 78 (1 m, CSL; 1 m).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Bebbia juncea (Asteraceae).

### Family Lycaenidae

Satyrium behrii behrii (Edwards).

Rare with records between early June and mid July. It may be more widespread than presently known in the Pinon-Juniper belt where its foodplant, *Purshia* is not uncommon.

SPECIMENS EXAMINED: (17) WC, 5 June 79 (2 m), 11 June 79 (9 m, 1 f), 22 June 68 (1 m), 22 June 78 (4 m).

ADDITIONAL RECORDS: MS, 23 June 65 (PJH), 30 June 63 (KR); WC, 13 July 72 (DEA).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare (Lamiaceae).

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Ministrymon leda (Edwards).

Locally common in association with *Prosopis glandulosa* in Paradise Valley near Las Vegas and scattered records elsewhere. There appear to be 2 broods. Most individuals are typical *leda* although there are single spring and fall specimens of form "ines" from Hidden Valley.

SPECIMENS EXAMINED: (30) Hidden Valley, 13 Apr. 78 (1 f "ines"), 12 July 77 (1 f), 16 Oct. 77 (1 m "ines"); GC, 1 June 78 (2 m), 3 July 78 (1 f); Lovell Wash, 7.5 mi. N. Pahrump Rd., 22 June 77 (1 f); PV, 9 May 78 (1 m), 24 June 78 (1 m), 18 July 77 (4 m, 4 f), 26 July 77 (2 m, 4 f), 31 July 77 (4 f); 27 June 66 (1 m); KC, 17.1 mi. W. U.S. 95 (1 m); WC, 19 Aug. 77 (1 f).

ADDITIONAL RECORDS: PV, 26 May 79, 3 July 77, 2 Aug. 77 (s).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Eriodictyon angustifolium (Hydrophyllaceae); Acacia greggii, Prosopis glandulosa (Fabaceae); Helianthus annuus, Baileya multiradiata (Asteraceae).

Callophrys fotis fotis (Strecker).

Usually uncommon but in some years exceedingly abundant, at least locally, at middle elevations from 4000' to 6800', always in association with *Cowania mexicana*. The flight period is from late March to mid May. Fresh specimens from Cold Creek on 13 June 1977 are undoubtedly from a partial second brood perhaps in response to early June rainfall.

SPECIMENS EXAMINED: (230) GS, 28 Mar. 68 (1, NSM); Lost Creek, 29 Mar. 78 (2 m, 1 f); CC, 8 Apr. 79 (1 m, 1 f); 2 mi. N. RC, 9 Apr. 79 (3 m), 15 Apr. 79 (7 m, 8 f); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 16 Apr. 77 (4 f); 16 Apr. 79 (5 m, 7 f); White Rock Spring, 21 Apr. 79 (1 m, 9 f); WC, 23 Apr. 78 (7 m, 6 f), 27 Apr. 77 (30 m, 33 f; 12 m, 13 f, NSM), 29 Apr. 77 (12 m, 2 f, NSM), 8 May 78 (2 m, 2 f), 13 June 77 (1 f); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 24 Apr. 77 (18 m, 22 f), 28 Apr. 77 (3 m); WC, 27 Apr. 77 (5 m, 2 f), 8 May 78 (1 f); 1 mi. W. RD Summit, 28 Apr. 77 (2 m, 1 f, NSM); KC, 15.7 mi. W. U.S. 95, 1 May 77 (2 m, 1 f); KC, 17.1 mi. W. U.S. 95, 2 May 77 (1 f); LC, 6 May 62 (1 m); Charleston Mts., 12 May 34 (1 f, LACM).

ADDITIONAL RECORDS: GS, 23 Mar. 68 (1968 summ.), 20 Apr. 75 (JB); RD, 23 Mar. 75 (JB, REW); RC, 24 Mar. 74 (REW), 24 Mar. 75 (JB), 7 Apr. 74 (REW); Potosi Mt. Rd., 6-8 Apr. 68 (REW); CP, 7 Apr. 74 (REW); RD near Calico Hills, 19 Apr. 75 (JB); White Rock Springs, 19 Apr. 75 (JB); CP Rd., 0.6-1.5 mi. S. Pahrump Rd., 20 Apr. 77, 29 Apr. 79 (s); KC, 6800', 3-4 May 75 (1975 summ.); 0.5 mi. E. MS, 13 May 79 (s).

LARVAL FOODPLANTS: Cowania mexicana var. stansburiana (Torr.) Jeps. (Rosaceae): WC, 27 Apr. 77 (ovip.).

ADULT RESOURCES: Ribes aureum (Saxifragaceae); Arctostaphylos pungens (Ericaceae); Salix lasiolepis (Salicaceae); Rhus trilobata (Anacardiaceae); Taraxacum officinale (Asteraceae).

Callophrys eryphon eryphon (Boisduval).

One relatively fresh male from the Virgin Mountains is the only county record. The nearest known Nevada population is in the Wilson Creek Range, Lincoln County (GTA, CSL).

SPECIMENS EXAMINED: (1) CC, 20 May 76 (1 m, NSM).

ADDITIONAL RECORDS: None.

Callophrys spinetorum (Hewitson).

Uncommon at middle elevations from 4400' to 7000'. It flies in 2 broods from early

April to late May and early June to early August. The earlier brood occurs mainly below 6000'; later brood is mainly above 6000'. Adults are particularly fond of the flowers of *Eriodictyon*. Males commonly perch on ridge-top pinons and junipers.

SPECIMENS EXAMINED: (42) White Rock Springs, 21 Apr. 79 (11 m); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 24 Apr. 77 (3 f), 28 Apr. 77 (2 f); 0.5 mi. E. MS, 13 May 79 (8 m); WC, 25 May 78 (1 m), 5 June 79 (1 m), 11 June 79 (1 m), 20 July 78 (1 m, 1 f), 28 July 77 (1 m); Deer Creek Rd., 7000', 3 July 61 (2 m); Lovell Wash, 6100-6600', 14 July 62 (1 m, 3 f), 18 July 62 (3 m, 3 f).

ADDITIONAL RECORDS: Potosi Mt. Rd., 6 Apr. 74 (REW), 8 Apr. 71 (REW); WC, 27 Apr. 77, 30 May 66 (s); Willow Springs, 10 May 66 (JFL); Mt. Charleston, 15 June 40 (Shields 1965); RD Summit Rd., 1.5 mi. E. Lovell Wash, 22 June 77 (s); SM, 7000', 23 June 61 (KR); LC, 6000', 23 June 61 (KR); Charleston Peak, 29 June 35 (Howe 1975); WC, 13 July 72 (DEA), 16 July 72 (JFL); Charleston Mts., 6 Aug. 61 (1961 summ.).

ADULTRESOURCES: Clematis ligusticifolia (Ranunculaceae); Arctostaphylos pungens (Ericaceae); Eriodictyon angustifolium (Hydrophyllaceae); Salix lasiolepis (Salicaceae); Rhus trilobata (Anacardiaceae); Tetradymia canescens (Asteraceae). Callophrys siva siva (Edwards).

Fairly common at the middle elevations in the Pinon-Juniper belt. It flies in 2 broads from late March to late May and early June to late July with some variation depending on elevation.

Clark County material is assigned to nominate siva on the advice of John Lane. All populations in the county, however, show some intermediacy with the unnamed Great Basin brown population occurring farther north.

SPECIMENS EXAMINED: (131) CC, 8 Apr. 79 (2 m), 20 May 79 (1 f); MM, 12 Apr. 69 (1 m, NSM); 2 mi. N. RC, 15 Apr. 79 (4 m, 2 f); CP Rd., 1.8 mi. S. Pahrump Rd., 16 Apr. 77 (1 f); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 24 Apr. 77 (1 m, 2 f), 28 Apr. 77 (1 m; 1 f, CSL), 2 June 77 (1 m, 1 f), 22 June 77 (4 m, 7 f), 27 July 77 (1 m); WC, 27 Apr. 77 (1 m, 1 f), 29 Apr. 77 (2 m, 1 f, CSL; 1 f, NSM) 30 May 66 (1 m), 6 June 78 (1 m, 1 f), 13 June 77 (2 f), 22 June 78 (1 m, 3 f), 4 July 62 (1 f), 28 July 77 (1 m); WC, 27 Apr. 77 (1 f), 5 June 79 (6 m, 3 f), 6 June 78 (1 f), 11 June 79 (23 m, 10 f), 22 June 68 (1 f), 22 June 78 (1 f), 1 July 77 (1 m, 1 f); KC, 5680', 1 May 66 (1 m); Pine Creek, 2 May 77 (1 f); 0.5 mi. E. MS, 13 May 79 (2 f); Charleston Mts., 14 May 34 (1 f, LACM); Potosi Mt. Rd. at Pahrump Rd., 2 June 77 (1 m); Trout Canyon Rd., 14 June 77 (5 m, 2 f); KC, 14.5 mi. W. U.S. 95, 14 June 77 (1 m), 20 June 77 (1 m), 20 June 79 (1 m, 1 f), 6 July 77 (2 m); Lovell Wash, 22 June 77 (3 m), 14 July 62 (1 m, 1 f), 18 July 62 (1 m, 2 f), 27 July 77 (1 m); LC at Mack's Canyon Rd., 23 June 77 (1 f); Mormon Well, 1 July 69 (1, LACM); 26 mi. E. CN, Mormon Well Rd., 1 July 69 (1, LACM); Sawmill Canyon, 6000-7000', 2 July 69 (5, LACM); KC, 17.1 mi. W. U.S. 95, 5 July 78 (2 f); Cold Creek Ranger Station, 20 July 77 (2 m).

ADDITIONAL RECORDS: Early spring specimens have also been taken near GS, 23 Mar. 77 (KBT); Pine Creek, 23 Mar. 72 (JFL): RC, 24 Mar. 75 (JB) and Potosi Mt. Rd., 8 Apr. 71 (REW). Additional records are for locations and span of dates listed above.

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Stanleya pinnata (Brassicaceae); Eriogonum microthecum, Eriogonum umbellatum (Poly gonaceae); Arctostaphylos pungens (Ericaceae); Sarcostemma cynachoides (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Cryptantha jamesii (Boraginaceae); Melilotus albus, Trifolium repens (Fabaceae); Salix sp. (Salicaceae); Rhus trilobata

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(Anacardiaceae); Viguiera multiflora, Baccharis sp., Senecio douglasii, Senecio multilobatus, Tetradymia canescens (Asteraceae).

Callophrys sheridanii comstocki Henne.

Locally common with all records except one (Virgin Mountains) for the higher desert area between Goodsprings and Mountain Springs Summit. There are two broods from late March to early May and late August to mid September. The fall brood is more yellow-green below than the spring brood as found in California populations (Emmel and Emmel 1973).

SPECIMENS EXAMINED: (152) 0.7 mi. NNW Wilson Pass (4 m, JFE); Wilson Pass, 25 Mar. 78 (1 m), 29 Mar. 78 (1 m); CC, 29 Mar. 71 (1 f, NSM); 6 mi. N. GS, 4 Apr. 77 (10 m, 3 f, DM); 2-3.3 mi. N. RC, 5 Apr. 78 (9 m, NSM; 30 m, 1 f), 11 Apr. 78 (2 m, NSM), 15 Apr. 79 (39 m), 4 May 78 (1 m), 21 Aug. 79 (11 m), 26 Aug. 79 (2 m, 1 f), 2 Sept. 78 (21 m, 9 f), 3 Sept. 78 (2 m, NSM), 8 Sept. 78 (2 m, NSM), 11 Sept. 78 (2 m).

ADDITIONAL RECORDS: GS, 23 Mar. 68 (Callaghan 1970); RC, 24 Mar. 75 (JB, REW), 7 Apr. 74 (REW); Potosi Mt. Rd., 6 Apr. 71 (REW); GS, 11 Apr. 71 (s); N. GS, 20 Apr. 75 (JB).

LARVAL FOODPLANTS: Eriogonum heermannii Dur. & Hilg. var. sulcatum (S. Wats.) Munz & Reveal (Polygonaceae): 2-3 mi. N. RC, several dates (adult assoc.).

ADULT RESOURCES: Eriogonum heermannii, Eriogonum microthecum (Polygonaceae); Rhus trilobata (Anacardiaceae); Chrysothamnus sp. (Asteraceae).

Atlides halesus concorani (Clench).

Locally common in the valleys in stands of *Prosopis* or *Acacia* on which its foodplant, *Phoradendron californicum*, is parasitic. The flight period extends from late February to mid November involving at least 4 broods with peaks in early April, early June, late July and October. The last 2 broods appear to be more numerous than earlier broods. There are a few high elevation specimens which may represent strays or small colonies on *Phoradendron juniperinum*.

SPECIMENS EXAMINED: (106) Records extend from 25 Feb. (78, PV, 1 f) to 11 Dec. (77, GC, 1 f). High elevation specimens are: 0.5 mi. E. MS, 13 May 79 (2 m), 19 May 78 (2 m); WC, 28 July 77 (1 f); WC, 6 June 78 (2 f).

LARVAL FOODPLANTS: Phoradendron californicum Nutt. (Viscaceae) on Prosopis glandulosa: PV, 18 July 77 (ovip.).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Eriogonum fasciculatum, Eriogonum plumatella, Eriogonum sp. (Polygonaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Acacia greggii, Prosopis glandulosa (Fabaceae); Salix sp. (Salicaceae); Sambucus caerulea (Caprifolicaceae); Bebbia juncea, Solidago spectabilis, Baccharis sp., Senecio douglasii, Tetradymia canescens, Pluchea sericea (Asteraceae).

Strymon melinus pudica (H. Edwards).

Common, especially in agricultural areas, but with records for a variety of habitats to 9000'. The flight period extends from late March through mid November involving several broods. Desert records are for spring and fall. Clark County material is tentatively assigned to the California race on the advice of Glenn A. Gorelick pending completion of his study on this species.

'SPECIMENS EXAMINED: (209) Records for numerous locations between 25 Mar. 79, XM, (1 m) and 16 Nov. (77, KC, s); high elevation records extend from 30 May (66, WC, 1 m) to 26 Oct. (77, WC, 1 f).

ADULT RESOURCES: Tamarix pentrandra (Tamaricaceae); Eriogonum fasciculatum, Eriogonum heermanni, Eriogonum plumatella, Eriogonum umbellatum, Eriogonum wrightii (Polygonaceae); Apocynum androsaemifolium (Apocynaceae); Sarcostemma hirtellum (Asclepiadaeae); Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare (Lamiaceae); Fallugia paradoxa (Rosaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Medicago sativa, Melilotus albus (Fabaceae); Helianthus annuus, Bebbia juncea, Baileya pleniradiata, Hymenoxys cooperi, Solidago spectabilis, Chrysothamnus sp., Baccharis sp., Senecio douglasii, Tetradymia axillaris, Tetradymia canescens, Pluchea sericea, Cirsium sp. (Asteraceae). Lycaena helloides (Boisduval).

Locally common in agricultural areas of Moapa and Virgin valleys. There are at least 3 broods in a season ranging from mid April to late October. The fall brood is by far the largest, peaking in early to late October. The larvae undoubtedly feed on Rumex sp. which commonly borders fields and adults are often taken at Medicago flowers.

SPECIMENS EXAMINED: (56) LO, 13 Apr. 78 (1 m), 10 July 68 (1 m), 9 Aug. 77 (1 m, 2 f), 23 Aug. 77 (1 f), 17 Sept. 77 (1 f), 28 Sept. 67 (2 m, NSM), 28 Sept. 68 (2 f, NSM), 9 Oct. 77 (1 m, 9 f), 10 Oct. 64 (6 m, 12 f, NSM), 16 Oct. 77 (7 m, 4 f), 21 Oct. 79 (1 m); OV, 7 June 77 (1 m); Hidden Valley, 23 Oct. 77 (1 m, 3 f).

ADDITIONAL RECORDS: Bunkerville, 17 May 78 (s); Hidden Valley, 7 June 77 (s); LO, 27 June 77, 30 July 77, 4 Sept. 77, 29 Sept. 77, 23 Oct. 77 (s).

ADULT RESOURCES: Convolvulus sp. (Convolvulaceae); Medicago sativa (Fabaceae); Helianthus annuus, Baccharis sp. (Asteraceae).

Lycaena dorcas castro (Reakirt).

The single southern Nevada record was reported by Ferris (1977) from Charleston Park (Kyle Canyon). If a colony once occurred here, it apparently no longer exists as there are no recent records for this well collected area. The specimen may be mislabelled.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: Charleston Park, 8000', 26 July 28 (1 m, fide CDF). Brephidium exilis (Boisduval).

Locally abundant in somewhat alkaline areas of valleys, otherwise rare to common in a variety of habitats to elevations of 8400'. The flight period at low elevations is from early March to mid December and at high elevations from early May to mid November. The lateness of the first records at high elevations suggests no overwinter survival there. Reproduction (2-3 broods) occurs at least as high as 6800' where the species is associated with Atriplex canescens. At low elevations, 4 to 5 or more overlapping broods are produced.

SPECIMENS EXAMINED: (513) Many records from virtually throughout the county. In the lowlands earliest and latest records are 3 Mar. (67, LO, NSM) and 12 Dec. (77, Tule Springs, s). Montane records are from 8 May (78, WC) to 12 Nov. (77, WC, s).

LARVAL FOODPLANTS: Atriplex canescens (Pursh) Nutt. ssp. linearis (Wats.) Hall & Clements (Chenopodiaceae): several locations, many dates (adult assoc.). Suaeda torreyana Wats. (Chenopodiaceae): Hidden Valley, 9 Oct. 77 (larvae); several locations, many dates (adult assoc.). Salsola spp. (probably including S. iberica Sennen & Pau. and S. paulsenii Litv., see Beatley 1976) (Chenopodiaceae): many locations, many dates (adult assoc.).

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ADULT RESOURCES: Sphaeralcea ambigua (Malvaceae); Tamarix pentandra (Tamaricaceae); Lepidium fremontii (Brassicaceae); Eriogonum fasciculatum, Eriogonum heermannii, Eriogonum wrightii, Polygonum lapathifolium (Polygonaceae); Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Prosopis glandulosa, Medicago sativa, Melilotus albus (Fabaceae); Rhus trilobata (Anacardiaceae); Viguiera multiflora, Bebbia juncea, Baileya pleniradiata, Baileya multiradiata, Chrysothamnus sp., Baccharis sp., Senecio douglasii, Senecio multilobatus, Cirsium sp., (Asteraceae).

Leptotes marina (Reakirt).

Common to abundant in a variety of habitats to 7000' with occasional occurrences as high as 11,000'. The flight season is from late March to mid November at low elevations and from late April to late August at high elevations. Desert records are mainly from March to May. At least 3 broods are produced in mesquite habitat (May, June, July), continuous broods in agricultural areas (May-October) and a single brood at high elevations (June-July).

SPECIMENS EXAMINED: (403) Numerous records at many locations at low elevations with records from 25 Mar. (72, 9 mi. W. Davis Dam, REW) to 12 Nov. (77, Tule Springs, s). High elevation records are few but widespread from 29 Apr. (77, WC, CSL) to 26 Oct. (77, WC, 1 m).

LARVAL FOODPLANTS: Acacia greggii Gray (Fabaceae): PV, 8 June 77 (ovip. at base of flower buds). Prosopis glandulosa Torr. (Fabaceae): 0.5 mi. E. Blue Diamond, 22 May 78 (ovip. on flower buds, 09:30 PST).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Larrea tridentata (Zygophyllaceae); Tamarix pentandra (Tamaricaceae); Sisymbrium altissimum, Rorippa nasturtium-aquaticum (Brassicaceae); Eriogonum sp., Eriogonum fasciculatum (Polygonaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Medicago sativa, Melilotus albus, Trifolium repens (Fabaceae); Rhus trilobata (Anacardiaceae); Viguiera deltoidea, Bebbia juncea, Baileya multiradiata, Chaenactis fremontii, Haplopappus sp., Baccharis sp., Senecio douglasii, Tetradymia canescens, Pluchea sericea, Cirsium sp. (Asteraceae).

Hemiargus ceraunus gyas (Edwards).

Fairly common throughout at elevations below 7800' and occasional to 11,000'. The flight period at low elevations is from early April to mid November. Along small desert washes, there are broods in April-May and October-November; in mesquite stands and agricultural areas, there is a large brood flying from early July through mid September depending on location and with scattered individuals at other times of the year and at high elevations, there are at least 2 broods peaking in July and October.

SPECIMENS EXAMINED: (179) Numerous records, especially at low elevations from 4 Apr. (77, PV, s) to 12 Dec. (77, Tule Springs, s). High elevation records are from 13 June (77, WC, 1 f) to 12 Nov. (77, WC, 3 m).

LARVAL FOODPLANTS: *Psorothamnus fremontii* (Torr.) Barneby (Fabaceae): RR, 14 May 77 (ovip. on new leaf growth, 10:30 PST); U.S. 93, 5 mi. N. I-15, 14 May 78 (ovip. on leaf buds, 09:15 PST).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Eriogonum deflexum, Eriogonum fasciculatum, Eriogonum wrightii (Polygonaceae); Physalis cras-

sifolia (Solanaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Medicago sativa, Melilotus albus, Psorothamnus fremontii (Fabaceae); Bebbia juncea, Chaenactis fremontii, Palafoxia linearis, Erigeron sp., Senecio douglasii, Tetradymia axillaris (Asteraceae).

Hemiargus isola alce (Edwards).

Commoner than the above with an equally broad ecological range but has a more restricted season. Records extend from early April to late July at low elevations and from late April to early August (once late October) at high elevations. Desert records are for a single broad in April and May, at least 3 broads are produced in mesquite stands (April, May, July) and a single broad flies in July at high elevations. This species is outnumbered by *ceraunus* only in agricultural areas.

SPECIMENS EXAMINED: (212) Numerous records from many locations to 11,000'. Records extend from 8 Apr. (77, several locations) to 31 July (77, PV s) at low elevations and 18 Apr. (77, KC, 17.1 mi. W. U.S. 95, 1 f) to 5 Aug. (77, WC, 1 f and Cold Creek, 1 m) at high elevations. One very late specimen on 26 Oct. 77 (WC, 1 m).

ADULT RESOURCES: Sisymbrium altissimum (Brassicaceae); Eriogonum umbellatum (Polygonaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Melilotus albus, Melilotus officinalis, Trifolium repens (Fabaceae); Rhus trilobata (Anacardiaceae); Viguiera multiflora, Baileya pleniradiata, Tetradymia axillaris, Senecio douglasii, Pluchea sericea, Cirsium sp. (Asteraceae).

Plebejus melissa melissa (Edwards).

Rare in agricultural areas of Moapa Valley in fall with records from early September to late October. Clark County material is tentatively assigned to the nominate race but may represent an undescribed subspecies. The insect is fairly small, the wings (especially the hindwing) appear more rounded than those of other populations examined and the females are quite dark with barely a hint of basal blue overscaling.

SPECIMENS EXAMINED: (7) OV, 4 Sept. 66 (2 m, 1 f); LO, 4 Sept. 66 (1 m), 16 Oct. 77 (1 m, 1 f); Hidden Valley, 23 Oct. 77 (1 f).

ADDITIONAL RECORDS: OV, 29 Sept. 66, 10 Oct. 64 (PJH).

Plebejus icarioides evius (Boisduval).

Common to abundant in stands of *Lupinus* above 6400' mainly in the Kyle Canyon and Lee Canyon areas of the Spring Range. The flight period of the single brood is from mid May to early September. There are records from the Virgin Mountains from mid May to late June and in early October.

The Spring Range specimens are of large size with relatively strong maculation and fit closest to the concept of evius. The females are variable and over 60% have orange scaling on the hindwing above. The few specimens from the Virgin Mountains are smaller in size, have reduced maculation beneath and the females have increased black scaling on the forewing above and no orange scaling. They thus tend towards the Great Basin  $P.\ i.\ ardea$  (Edwards).

SPECIMENS EXAMINED: (316) Numerous records for the Spring Range to 11,300' from 12 May (34, Charleston Mts. 1 f, LACM) to 1 Sept. (77, KC Ski Run, 6 m, 3 f). Also recorded in the Virgin Mountains: 20 May 79 (1 m), 30 May 74 (2 m, 1 f, NSM), 7 June 78 (s), 26 June 78 (2 m, 3 f), 7 Oct. 73 (1 f, NSM).

ADULT RESOURCES: Linum lewisii (Linaceae); Eriogonum umbellatum (Poly-

gonaceae); Potentilla propinqua (Rosaceae); Lupinus sp., Melilotus albus (Fabaceae); Chaenactis douglasii, Erigeron sp., Senecio douglasii (Asteraceae).

Plebejus shasta charlestonensis Austin.

Usually rare (may be common in some years) in Kyle and Lee canyons above 8200' and in the Willow Creek area at 6000' to 8000'. The flight period of the single brood is from early July to mid August. This taxon was recently described by Austin (1980).

SPECIMENS EXAMINED: (17) LC Ski area, 5 July 76 (1 m, DM); LC, 8250'-8800', 21 July 63 (7 m, 7 f); KC, 9000', 25 July 65 (1 m); KC, 8500', 27 July 65 (1 m).

ADDITIONAL RECORDS: Deer Creek Rd., 7000', 1 July 50 (FWP, figured in Howe 1975); Cathedral Rock, 10 July 72 (DEA); WC, 6000-8000', 15 July 28 (Gunder colln. at American Museum of Natural History, fide JFE); LC Ski Area, 12-17 Aug. 63 (JFL).

Plebejus acmon acmon (Westwood & Hewitson).

This taxon is known in the county only from the Newberry Mountains and a single specimen from Las Vegas. The flight period is from late March to late October. The Newberry Mountains' population of  $P.\ acmon$  (referred to as  $acmon\ acmon$ ) has a pinkish-orange submarginal band on the secondaries and a narrow, non-infusive dark margin on the primaries. All other Clark Co. populations (referred to as  $acmon\ texanus$ ) have an orange (with no pink tinge) submarginal band on the secondaries. The dark margin on the primaries is broad with an indistinct inner border.

SPECIMENS EXAMINED: (15) XM, 12 May 78 (1 f), 23 May 78 (1 f), 1 June 78 (1 m, 2 f), 3 July 78 (1 f), 21 July 78 (1 m, 1 f), 4 Aug. 78 (1 f); Las Vegas, 29 June 62 (1 m); GC, 3 July 78 (1 m, 1 f) 21 July 78 (1 m), 4 Aug. 78 (1 m), 29 Oct. 78 (1 m).

ADDITIONAL RECORDS: 9 mi. W. Davis Dam, 31 Mar. 77 (CSL); XM, 21 May 73 (PJH); GC, 26 Sept. 78 (s).

ADULT RESOURCES: Eriogonum fasciculatum, Eriogonum plumatella (Polygonaceae); Tetradymia axillaris (Asteraceae).

Plebejus acmon texanus Goodpasture.

This race of *acmon* constitutes the bulk of records for the species in Clark County. It is found throughout except in the Newberry Mountains and at the highest elevations. It flies in several broods from late March to late October.

SPECIMENS EXAMINED: (230) Many locations and dates between 28 Mar. (71, 6 mi. N. Apex, 1 m, NSM) and 26 Oct. (77, WC, 1 m).

ADULT RESOURCES: Eriogonum umbellatum (Polygonaceae); Sarcostemma cynachoides (Asclepiadaceae); Eucrypta micrantha, Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Crypthantha sp. (Boraginaceae); Potentilla propingua (Rosaceae); Melilotus albus, Astragalus lentiginosus (Fabaceae); Viguiera multiflora, Eriophyllum wallacei, Tetradymia canescens, Cirsium sp. (Asteraceae). Everes amyntula (Boisduval).

Uncommon in the Spring Range at elevations between 6000' and 9000'. It appears to be single brooded with records from mid May to late July and single records in late August and early October.

SPECIMENS EXAMINED: (28) Charleston Mts., 12 May 34 (5 m, LACM); WC, 25 May 78 (1 m), 5 June 79 (1 m²), 6 June 78 (1 m), 13 June 77 (1 m), 22 June 68 (2 m), 22 June 78 (1 m), 30 Aug. 77 (1 m), 1 Oct. 73 (1 m, UNLV); KC Campground, 31 May 77 (2 m), 8 June 77 (2 m, 3 f), 17 June 77 (1 m); WC, 13 June 77 (1 m), 28 July 77 (2 m); above Cathedral Rock Campground, 17 June 77 (1 m); LC Ski Area, 29 July 77 (1 m, 1 f).

ADDITIONAL RECORDS: WC, 1 July 77 (s), 13 July 72 (DEA), 16 July 72 (JFL), 28 July 77 (s); KC Campground, 22 June 78 (s).

ADULT RESOURCES: Eriogonum umbellatum (Polygonaceae).

Euphilotes battoides nr. ellisii (Shields).

A population with a phenotype similar to that of populations in desert mountains of eastern California flies during August and September in the southern Spring Range. We have been unable to find it around its suspected foodplant in other portions of the Spring Range.

The use of the genus Euphilotes follows Mattoni (1977).

SPECIMENS EXAMINED: (22) 2-3.3 mi. N. RC, 19 Aug. 79 (2 m), 21 Aug. 79 (1 m, 2 f), 26 Aug. 79 (1 m, 1 f), 2 Sept. 78 (1 m, 6 f), 3 Sept. 78 (1 f, NSM), 8 Sept. 78 (1 m, 2 f, NSM; 2 f); 11 Sept. 78 (2 f).

ADDITIONAL RECORDS: None.

LARVAL FOODPLANTS: Eriogonum heermannii Dur. & Hilg. var. sulcatum (S. Wats.) Munz & Reveal (Polygonaceae): 3 mi. N. RC, 2, 11 Sept. 78 (adult assoc.). ADULT RESOURCES: Eriogonum heermanni (Polygonaceae).

Euphilotes battoides martini (Mattoni).

Common in association with *Eriogonum fasciculatum* especially in the Newberry Mountains. Smaller populations occur in the Spring, Virgin and Las Vegas ranges. The flight period is from mid March to late May.

SPECIMENS EXAMINED: (357) Newberry Mts., 8 Apr. 70 (1 m, NSM); 9 mi. W. Davis Dam, 8 Apr. 77 (5 m, 1 f, NSM; 7 m, 4 f), 20 Apr. 78 (9 m, NSM; 7 m, 3 f), 22 Apr. 79 (12 m, 12 f), 1 May 75 (1 m, 1 f, NSM); 3 May 78 (9 m, 12 f), 12 May 78 (1 m, 1 f), 23 May 78 (1 m); GC, 8 Apr. 78 (2 m, 1 f, NSM); 3 m, 1 f), 12 Apr. 78 (1 m, NSM); 2 m, 2 f), 15 Apr. 78 (5 m, 1 f), 20 Apr. 78 (4 m, NSM); 12 m, 1 f), 3 May 78 (8 m, 5 f); XM, 22 Apr. 79 (39 m, 2 f), 3 May 78 (25 m, 22 f), 5 May 77 (4 m, 12 f, NSM); 6 m), 6 May 79 (29 m, 30 f), 12 May 78 (5 m, 6 f), 23 May 78 (4 f); Pine Creek, 2 May 77 (1 m), 22 May 78 (3 m, 4 f); Bridge Canyon, 3 May 78 (4 m, 3 f); CC, 10 May 78 (3 m, 1 f), 17 May 78 (5 m, 5 f), 18 May 78 (2 m, 1 f), 20 May 79 (1 f); U.S. 93, 5-8 mi. N. I-15, 14 May 78 (1 m, 4 f).

ADDITIONAL RECORDS: GC, 18 Mar. 72 (JFL), 12 May 78 (s); XM, 18 Mar. 72 (JFL), 20 Apr. 78 (s); 9 mi. W. Davis Dam, 25 Mar. 72 (REW), 31 Mar. 77 (CSL); CC, 20 May 78, 29 May 78 (s).

LARVAL FOODPLANTS: Eriogonum fasciculatum Benth. ssp. poliofolium (Benth.) S. Stokes (Polygonaceae): 9 mi. W. Davis Dam, 8 Apr. 77 (ovip. on flower heads, 10:00 PST); GC, several dates (adult assoc.); XM, several dates (adult assoc.); Pine Creek, 2 May 77, 22 May 78 (adult assoc.); CC, several dates (adult assoc.); U.S. 93, 5-8 mi. N. I-15, 14 May 78 (adult assoc.).

ADULT RESOURCES: Eriogonum fasciculatum (Polygonaceae); males and, occasionally females visit mud.

Euphilotes battoides baueri (Shields).

This taxon has been recorded once in Clark County. It was originally reported as "Philotes" mojave collected on 14 April 1969 (1969 summ.); the specimens are the only ones located in Nevada State Museum bearing the date of 13 May 1969. We retain the label date but point out the strong possibility that the correct one is in April (see introduction) or that these specimens are not from Clark County.

SPECIMENS EXAMINED: (2) AC, 13 May 69 (1 m, 1 f, NSM). This record also was reported by Shields (1975).

ADDITIONAL RECORDS: None.

Euphilotes enoptes (Boisduval) ssp.

A nearly purple, heavily marked population of *enoptes* occurs in the Spring Range between 6100' and 7200'. It flies in association with *Eriogonum umbellatum* from early June to mid August. This unnamed population has been variously referred to as near *E. e. enoptes* and *E. e. ancilla* (Barnes & McDunnough).

SPECIMENS EXAMINED: (192) WC, 5 June 79 (60 m), 6 June 78 (53 m), 11 June 79 (33 m), 13 June 77 (9 m), 20 July 77 (7 m, 1 f); end KC, 2 July 36 (1 m, LACM); KC Campground, 25 July 77 (2 m, 1 f); WC, 20 July 78 (10 m, 5 f), 28 July 77 (5 m, 4 f), 19 Aug. 77 (1 m).

ADDITIONAL RECORDS: WC, 17 June 77 (s), 16 July 72 (JFL), 28 July 77 (s); Mt. Charleston, 7200', 26 June 59 (Shields 1977); KC, 17.1 mi. W. U.S. 95, 6 July 77 (s); KC, 7100', 14 July 66 (Shields 1977).

LARVAL FOODPLANTS: Eriogonum umbellatum Torr. var. subaridum S. Stokes (Polygonaceae): WC, 28 July 77 (ovip. on flowers, 08:30 PST).

ADULT RESOURCES: Eriogonum umbellatum (Polygonaceae); males frequent mud.

Euphilotes enoptes dammersi (Comstock & Henne).

The only records are from mid September to early October in the Newberry Mountains and in the Spring Range at Pine Creek. The one previous record for Nevada is for Lincoln County (Shields 1977).

SPECIMENS EXAMINED: (55) GC, 13 Sept. 78 (2 m, NSM), 20 Sept. 78 (1 m, 2 f, NSM; 4 m, 4 f), 26 Sept. 78 (2 m, 3 f, NSM; 2 m 5 f), 27 Sept. 77 (3 m), 4 Oct. 77 (6 m, 2 f); XM, 13 Sept. 78 (1 m, 2 f); Pine Creek, 19 Sept. 78 (1 m), 19 Sept. 79 (3 m, 5 f), 22 Sept. 78 (2 m, 5 f).

ADDITIONAL RECORDS: Sacatone Wash, 26 Sept. 78 (s).

LARVAL FOODPLANTS: Eriogonum wrightii Torr. ex Benth (Polygonaceae): GC, 4 Oct. 77 (ovip. on flower buds, 10:00 PST).

ADULT RESOURCES: Eriogonum plumatella, Eriogonum umbellatum, Eriogonum wrightii (Polygonaceae); males visit mud.

Euphilotes mojave (Watson & Comstock).

A population of this species was discovered in the Virgin Mountains in 1978. It flies from early May to early June at elevations between 3800' and 6000'. Although this population is undoubtedly *mojave* there are certain differences from nominate *mojave* and the population probably deserves a name. There are no previous Nevada records (those reported in the 1969 summ. are actually *battoides*, see above).

We agree with Mattoni (1977) that mojave deserves specific status and is not a race of enoptes as suggested by Shields (1975).

SPECIMENS EXAMINED: (84) CC, 10 May 78 (9 m), 18 May 78 (25 m, 9 f), 20 May 78 (6 m, 4 f), 20 May 79 (16 m, 10 f), 29 May 78 (1 m, 2 f), 7 June 78 (2 m). ADDITIONAL RECORDS: None.

LARVAL FOODPLANTS: Eriogonum nidularium Cov. (Polygonaceae): CC, 20 May 78 (abdominal probing near unopened flower buds, 13:55 PST).

ADULT RESOURCES: Eriogonum vimineum (Polygonaceae); Cryptantha sp. (Boraginaceae).

Philotiella speciosa speciosa (H. Edwards).

Two specimens are known from Clark County. One bears no date on its label but was apparently taken on 14 April 1969 (1969 summ., see introduction above;

Shields, 1974, reports this as a May specimen) and the other was taken in June. The genus *Philotiella* was recently proposed by Mattoni (1977).

SPECIMENS EXAMINED: (2) AC, no date (1 m, NSM); Willow Spring, 17 June 78 (1 m, ex DM).

ADDITIONAL RECORDS: None.

Glaucopsyche lygdamus (Doubleday) ssp.

Small numbers of this species fly from early April to mid May in the higher desert between Goodsprings and the Pahrump Road in the Cottonwood Pass area of the southern Spring Range. There is also one record for the McCullough Mountains. It appears to belong to the unnamed eastern Mojave Desert population that is known from several desert ranges in California (Emmel and Emmel 1973).

SPECIMENS EXAMINED: (113) MM, 12 Apr. 69 (1 m, NSM); CP, 0.6-1.8 mi. S. Pahrump Rd., 16 Apr. 77 (1 m), 16 Apr. 79 (65 m, 5 f), 22 Apr. 78 (5 m, 3 f), 29 Apr. 8 (7 m, 2 f), 29 Apr. 79 (14 m, 7 f), 2 May 78 (2 m), 11 May 78 (1 f).

ADDITIONAL RECORDS: CP and RC, 7 Apr. 74 (REW); 1 mi. N. CP, 12 Apr. 76 (JB); CP Road, 0.6 mi. S. Pahrump Rd., 20 Apr. 77 (s).

LARVAL FOODPLANTS: Astragalus lentiginosus Dougl. var. fremontii (A. Gray) S. Wats. (Fabaceae): CP Rd., 1.5 mi. S. Pahrump Rd., 22 Apr. 78 (abdominal probing among flowers).

ADULT RESOURCES: Dichelostemma pulchellum (Amaryllidaceae); Arabis sp. (Brassicaceae); Salvia dorrii (Lamiaceae); Astragalus lentiginosus (Fabaceae). Glaucopsyche lygdamus oro Scudder.

A few records from Kyle Canyon from mid June to late July indicate the presence of a small colony of this taxon in the Spring Range. It is associated with *Lupinus* and seems best placed in the Rocky Mountain-Great Basin race *oro*.

SPECIMENS EXAMINED: (4) above Cathedral Rock Campground, 8000', 17 June 77 (1 m, 1 f); KC Ski Run, 2 July 78 (1 f), 23 July 78 (1 m).

ADDITIONAL RECORDS: None.

Celastrina argiolus cinerea (Edwards).

Common to locally abundant at elevations between 3600' and 9500'. Records extend from mid March to late October. Early spring records especially are from the more mesic lower canyons with the first high elevation records in late April.

Early spring specimens tend to be smaller than those from later broods. Spring females have relatively narrow black borders above; summer females are heavily bordered with black, a form to which the name "arizonensis" has been applied.

SPECIMENS EXAMINED: (376) Many records from the Spring Range from 19 Mar. (72, Calico Basin, s) to 24 Oct. (65, Calico Basin, 1 m). There are a few records for the Virgin Mts. and one for the Newberry Mts. (GC, 20 Sept. 78, 1 m).

LARVAL FOODPLANTS: Petrophytum caespitosum (Nutt.) Rybd. (Rosaceae): Deer Creek, 25 June 68 (ovip. on flower buds, JFE, OS). Peraphyllum ramosissimum Nutt. (Rosaceae): RD Summit Rd., 1.5 mi. E. Lovell Wash, 24 April 77 (ovip. on flower buds).

ADULT RESOURCES: Eriogonum plumatella, Eriogonum umbellatum, Eriogonum wrightii (Polygonaceae); Arctostaphylos pungens (Ericaceae); Apocynum androsaemifolium (Apocynaceae); Sarcostemma cynachoides (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Potentilla propinqua (Rosaceae); Lupinus sp. Melilotus albus (Fabaceae); Acer glabrum (Aceraceae); Rhus trilobata (Anacardiaceae); Viguiera multiflora, Chrysothamnus sp., Senecio douglasii, Tetradymia canescens, Cirsium sp. (Asteraceae).

### Family Libytheidae

Libytheana bachmanii larvata (Strecker).

Usually uncommon to rare, but abundant in some years to 7600'. It occurs in most habitats but is most common along desert washes where *Chrysothamnus* is flowering. All except three records are from late August to mid December and probably represent migrants. The May and June records may be of individuals raised locally on *Celtis reticulata* which occurs rarely in the Red Rock area and in the Virgin Mountains. This remains to be documented.

SPECIMENS EXAMINED: (104) GC, 14 Sept. 77 (1 m), 4 Oct. 77 (1 f), 12 Oct. 77 (2 f), 25 Oct. 77 (7 m, 1 f), 3 Nov. 77 (2 m, 4 f), 11 Dec. 77 (2 m, 1 f); Bowman's Reservoir, 17 Sept. 77 (1 m); LO, 28 Sept. 66 (3, NSM), 16 Oct. 77 (1 f); Las Vegas, 3 Oct. 77 (1 m, UNLV); 2.9 mi. W. Searchlight, 4 Oct. 77 (1 m, 1 f); 1.8 mi. E. Blue Diamond, 11 Oct. 77 (1 m), 22 Oct. 77 (6 m, 1 f), 2 Nov. 77 (2 m, 1 f); WC, 14 Oct. 77 (1 f); KC Ski Run, 15 Oct. 77 (1 m); Whitney Mesa, 21 Oct. 77 (1 m, 4 f); Pahrump Rd., 3 mi. W. Blue Diamond turnoff, 22 Oct. 77 (14 m, 9 f); 0.6 mi. W. Blue Diamond, 22 Oct. 77 (1 f); Newberry Mts., 23 Oct. 70 (17, NSM); 2 mi. W. Searchlight, 25 Oct. 77 (3, NSM); Cold Creek Ranger Station, 26 Oct. 77 (3 m); WC, 26 Oct. 77 (1 m, 1 f); Tule Springs, 4 Nov. 77 (2 m); CN, 12 Nov. 77 (1 m, 1 f); 1 mi. W. MS, 16 Nov. 77 (1 f); KC, 20 mi. W. U.S. 95, 16 Nov. 77 (1 f); RD, 25 Nov. 77 (1 f, UNLV); PV, 28 Nov. 77 (1 f).

ADDITIONAL RECORDS: GC, 23 Mar. 78 (s); Willow Springs, 10 May 66 (JFL); MS, 30 June 63 (KR); Potosi Mt. Rd., 23 Aug. 75 (JB); CN, 1 Sept. 63 (KR); 14 Oct. 77, 26 Oct. 77, 4 Nov. 77 (s); 15.9 mi. W. Searchlight, 4 Oct. 77 (s); Las Vegas, 6 Oct. 70 (JFL); LO, 7 Oct. 64 (PJH); KC, 9.3 mi. W. U.S. 95, 15 Oct. 77 (s); jct. U.S. 93 and I-15, 23 Oct. 77, 5 Nov. 77 (s); Echo Canyon, 24 Oct. 77 (s); 0.2 mi. E. Boulder City, 25 Oct. 77 (s); WC, 26 Oct. 77 (s); Tule Springs, 1 Nov. 77, 12 Nov. 77, 12 Dec. 77 (s); 1.0 mi. W. MS, 1 Nov. 77 (s); UNLV campus, 1 Nov. 77 (s); 0.6 mi. W. Blue Diamond, 1 Nov. 77 (s); RR, 3 Nov. 77 (s); 0.5 mi. E. Boulder City, 3 Nov. 77 (s); 1.8 mi. E. Blue Diamond, 16 Nov. 77 (s).

ADULT RESOURCES: Eriogonum sp. (Polygonaceae); Melilotus albus (Fabaceae); Chrysothamnus sp., Baccharis sp., Senecio douglasii, Cirsium sp. (Asteraceae).

# Family Nymphalidae

Asterocampa celtis montis (Edwards).

A small population of this taxon occurs in association with *Celtis reticulata* in the Virgin Mountains. There are no other records for Nevada.

SPECIMENS EXAMINED: None.

ADDITIONAL RECORDS: 0.4 mi. N. Nay (Whitney on maps) Ranch, 11 Sept. 78 (KR), 11 Oct. 78 (s).

Limenitis archippus obsoleta Edwards.

Local in Moapa Valley in close association with stands of *Populus* and/or *Salix*. It flies in at least 2 broods from early June to late October; an early brood is suggested by a specimen from Beaver Dam, Mohave Co., Arizona, on 7 April 1963 (1 m). The June brood appears to be the most numerous.

SPECIMENS EXAMINED: (53) Hidden Valley, 7 June 77 (1 m), 27 June 77 (5 m), 12 July 77 (1 m), 9 Aug. 77 (1 m); Bowman's Reservoir, 7 June 77 (1 m), 15 June 77 (7 m, 3 f), 16 June 77 (1 m, NSM), 27 June 77 (4 m, 1 f), 4 July 77 (3 m), 30 July 77 (2 m), 23 Aug. 77 (1 m), 9 Oct. 77 (1 m); LO, 15 June 77 (1 m), 4 July 77 (1 m), 23

Aug. 77 (2 m), 9 Sept. 79 (1 m, 2 f), 27 Sept. 78 (3 m, 1 f), 9 Oct. 77 (2 m, 1 f), 16 Oct. 77 (1 m, 1 f), 21 Oct. 79 (1 m); OV, 16 June 77 (2 m, NSM), 10 Oct. 64 (2 f, NSM).

ADDITIONAL RECORDS: LO, 27 June 77, 9 Aug. 77 (s); Hidden Valley, 4 July 77, 30 July 77 (s); Bowman's Reservoir, 9 Aug. 77, 4 Sept. 77, 29 Sept. 77 (s); OV, 27 Sept. 78 (s), 1 Oct. 68 (1968 summ.).

Limenitis weidemeyerii angustifascia (Barnes & McDunnough).

A population assigned to this taxon flies in the Virgin Mountains in May and June. This material shows no intermediacy with nevadae. It is large with the more rounded wings of the Arizona race but has slightly wider median white bands. In this feature it is slightly intermediate towards L. w. latifascia Perkins & Perkins. Only one of the nine specimens examined has a trace of white in the cell.

SPECIMENS EXAMINED: (9) CC, 4000-6000', 29 May 78 (1 m), 7 June 78 (4 m), 26 June 78 (4 m).

ADDITIONAL RECORDS: CC, 20 May 79 (s); Virgin Mts., 7200', 30 June 66 (JFL).

Limenitis weidemeyerii nevadae (Barnes & Benjamin).

This distinctive taxon occurs in the Spring Range from 4400' in mesic canyons to about 8400'; it is most common in Kyle Canyon (above 6500') and in the Cold-Willow creeks area. There are also records of this race from the Sheep Range. The single brood flies from late May to late August with a peak in early July.

SPECIMENS EXAMINED: (183) Many records from 22 May (78, Pine Creek, 1 m) to 22 Aug. (77, KC Ski Run, 1 f).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare (Lamiaceae); Cirsium sp. (Asteraceae).

Adelpha bredowii eulalia (Doubleday).

Fairly common in certain low, mesic canyons and at high elevations in the vicinity of oaks. It occasionally strays as far as Las Vegas. The flight period at low elevations is from mid April to mid July and early September to early November. At high elevations, it flies from late May to early October. At least two broods are involved. The Spring Range population apparently represents the westernmost extreme of this subspecies' range.

SPECIMENS EXAMINED: (95) RD Springs, 14 Apr. 64 (1 m); Lost Creek, 3 May 77 (1 m, NSM), 2 June 77 (3 m, NSM); CC, 12 May 77 (1 m, NSM), 17 May 78 (1 m), 20 May 78 (1 m), 20 May 79 (1 m), 29 May 78 (6 m), 7 June 78 (4 m), 26 June 78 (2 m, 1 f), 28 Sept. 74 (4 m, 5 f, NSM), 11 Oct. 78 (1 m, 1 f); Pine Creek, 22 May 78 (3 m), 2 June 77 (1 m, NSM), 1 Sept. 75 (1 f, NSM), 12 Sept. 75 (1 f, NSM), 19 Sept. 77 (1 m, 1 f), UNLV), 24 Sept. 73 (2, UNLV), 29 Sept. 71 (1, UNLV), 5 Oct. 77 (1 m, 1 f); Virgin Mts., 30 May 74 (2 f, NSM), 7 Oct. 73 (1 m, 1 f, NSM); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 2 June 77 (1 f), 22 June 77 (1 m, 1 f); Willow Spring, 2 June 77 (2 m, NSM); WC, 22 June 68 (1 f), 13 Oct. 78 (1 m); Deer Creek Rd., 2.8 mi. N. KC, 26 June 79 (1 m); KC, 20 mi. W. U.S. 95, 28 June 78 (1 m), 5 July 78 (1 f), 25 Aug. 78 (2 m), 26 Sept. 77 (1 m); KC Campground, 24 June 79 (2 m, 1 f), 30 June 77 (1 f, NSM); Charleston Park, 30 June 77 (1 m, 2 f, NSM); KC Ski Run, 20 June 79 (2 m), 2 July 78 (1 f); KC, 7500', 15 July 74 (2 m, 1 f); Clark Co., 9 Sept. 73 (1, UNLV), 9 Sept. 74 (1, UNLV), 12 Sept. 76 (1, UNLV), 24 Sept. 73 (3, UNLV), 29 Sept. 71 (1, UNLV), 30 Sept. 76 (1, UNLV), 13 Oct. 74 (1, UNLV), 15 Oct. 74 (1, UNLV); KC, 11 Sept. 74 (2 f, NSM); RD, 23 Sept. 77 (1 m, UNLV), 15 Oct. 73 (1, UNLV);

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Las Vegas, 24 Sept. 74 (1, UNLV), Oct. 74 (1, UNLV), 21 Oct. 71 (1, UNLV), 10 Nov. 76 (1, UNLV); Lovell Canyon, 25 Sept. 75 (1 m, NSM).

ADDITIONAL RECORDS: Many additional records from locations and within the dates cited above. Additional collection sites are: MS, LC, Camp Bonanza, Arden Springs, Ash Springs and Oak Creek Canyon.

LARVAL FOODPLANTS: Quercus gambelii Nutt. (Fagaceae): RD Summit Rd., 22 June 77 (ovip.).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Chrysothamnus sp., Cirsium sp. (Asteraceae).

Vanessa atalanta rubria (Fruhstorfer).

Fairly common locally in fall during some years but rare at other times of the year. There are a few records of mostly single individuals from March to August and a large brood from late September to early November. The habitat of V. atalanta is generally adjacent to riparian areas although it is occasionally found away from these situations.

SPECIMENS EXAMINED: (49) CC, 10 May 78 (1 m); WC, 5 June 79 (1 f), 22 June 78 (2 m), 14 Oct. 77 (1 m, 1 f), 26 Oct. 77 (1 f); WC, 22 June 78 (1 f), 14 Oct. 77 (5 m, 6 f), 26 Oct. 77 (2 m, 3 f); Lovell Wash, 4475′, 17 June 62 (1 m); Clark Co., 15 July 74 (1, UNLV); Deer Creek, 21 Aug. 71 (1, UNLV); Lovell Wash, 25 Sept. 75 (1 f, NSM); KC, 20 mi. W. U.S. 95, 27 Sept. 78 (2 f); LO, 27 Sept. 78 (2 f); KC, 3998′, 9 Oct. 66 (1 f); KC, 6940′, 9 Oct. 66 (3 f); Tule Springs, 13 Oct. 77 (7, CSL), 14 Oct. 77 (1 f), 4 Nov. 77 (2 m); KC Ski Run, 13 Oct. 78 (1 m), 15 Oct. 77 (1 m); Echo Canyon, 24 Oct. 77 (1 m).

ADDITIONAL RECORDS: 9 mi. W. Davis Dam, 25 Mar. 79 (s); XM, 12 Apr. 78 (s); Hidden Valley, 13 Apr. 78 (s); White Rock Spring, 21 Apr. 79 (2); CP Rd., 1.5 78 (s); Hidden Valley, 13 Apr. 78 (s); White Rock Spring, 21 Apr. 79 (s); CP Rd., 1.5 mi. S. Pahrump Rd., 29 Apr. 79 (s); Lovell Wash, 5375′, 17 June 62 (s); WC, 11 June 79, 22 June 78, 1 July 77, 20 July 77 (s); KC Ski Run, 20 June 79, 2 July 78, 8 Oct. 77 (s); Lost Creek, 23 June 78 (s); LC ballfield, 29 July 77 (s); CN, 14 Oct. 77, 4 Nov. 77 (s); Echo Canyon, 15 Oct. 77 (s); KC Campground, 15 Oct. 77, 24 Oct. 77 (s); Tule Springs, 1 Nov. 77, 29 Nov. 77 (s).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Amsinckia tessellata (Boraginaceae); Marrubium vulgare (Lamiaceae); Melilotus albus (Fabaceae); aenactis sp. Haplopappus sp., Chrysothamnus sp., Baccharis sp. (Asteraceae).

Vanessa virginiensis (Drury).

Rare, occurring mostly at high elevations but also occasionally in desert washes and agricultural areas. It is apparently more common in some years than in others. It flies in 2 broods from mid June to early August and mid September to early November.

SPECIMENS EXAMINED: (19) Cold Creek Ranger Station, 13 June 77 (2 f); Potosi Mt. Rd. at Pahrump Rd., 14 June 77 (1 f); Overton, 15 June 77 (1 f); LC ballfield, 23 June 77 (1 m), 7 July 77 (1 m, NSM; 1 m); CC, 26 June 78 (1 m); KC, 20 mi. W. U.S. 95, 28 June 77 (1 m); ridge above KC, 11,200', 19 July 78 (1 m, 1 f); WC, 20 July 77 (1 m), 23 Sept. 77 (1 m); CN, 15 Sept. 64 (1 m, NSM); Lovell Canyon, 6000', 25 Sept. 75 (1 f, NSM); KC Ski Run, 8 Oct. 77 (1 m), 15 Oct. 77 (1 m); GC, 25 Oct. 77 (1 f); Tule Springs, 4 Nov. 77 (1 m).

ADDITIONAL RECORDS: Willow Creek, 17 June 77, 1 July 77 (s); KC Ski Run, 26 June 79, 2 July 78, 18 July 79 (s); GC, 21 July 78 (s); WC, 28 July 77, 14 Oct. 77, 26 Oct. 77 (s); Charleston Mts., 6 Aug. 61 (RES); 1.8 mi. E. Blue Diamond, 22 Oct. 77 (s).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Erysimum asperum (Brassicaceae); Eriodictyon angustifolium (Hydrophyllaceae); Lupinus sp., Medicago sativa, Melilotus albus (Fabaceae); Viguiera deltoidea, Encelia farinosa, Chrysothamnus sp., Senecio douglasii, Tetradymia canescens, Cirsium sp., Taraxacum officinale (Asteraceae).

Vanessa cardui (Linneaus).

Common to abundant in nearly all habitats. Low elevation records are for every month with desert records primarily in spring and fall. High elevation records are from early April to mid November. A large northward migration from 4 to 24 March 1968 with scattered individuals still moving into mid April (similar movements were seen at this time in Sonora, Mexico, and southern California, 1968 summ.). Large numbers in April 1973 and June and July 1965 (see also Emmel and Wobus 1966) showed no migratory tendencies and probably reflected favorable reproduction. The 1973 numbers were during one of the best local spring blooms of annuals on record; 1973 was a year of enormous numbers of the butterfly in California north to the Oregon border (Shaprio 1974). Several dwarfs were obtained in June and July 1965. Smaller scale movements also occur in other years (e.g., 1978) which may go unnoticed.

SPECIMENS EXAMINED: (202) Records are from every month and for nearly all locations in Clark County to the top of Charleston Peak.

LARVAL FOODPLANTS: Sphaeralcea ambigua Gray (Malvaceae): Las Vegas, several records (ovip., larvae). Althaea rosea (L.) Cav. (Malvaceae): Las Vegas, several records (ovip., larvae). Cirsium neomexicanum A. Gray (Asteraceae): 2 mi. N. RC, 5 Apr. 78 (ovip., 2x, upper leaf surface, 10:10 PST).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Tamarix pentandra (Tamaricaceae); Erysimum asperum (Brassicaceae); Eriogonum fasciculatum, Eriogonum heermannii, Eriogonum microthecum, Eriogonum sp. (Polygonaceae); Arctostaphylos pungens (Ericaceae); Menodora spinescens (Oleaceae); Apocynum androsaemifolium (Apocynaceae); Phacelia vallis-mortae, Eriodictyon angustifolium (Hydrophyllaceae); Sarcostemma hirtellum (Asclepiadaceae); Heliotropium curassavicum, Amsinckia tessellata (Boraginaceae); Mimulus guttatus (Scrophulariaceae) Verbena gooddingii (Verbenaceae); Marrubium vulgare (Lamiaceae); Medicago sativa, Melilotus albus, Psorothamnus fremontii (Fabaceae); Viguiera deltoidea, Helianthus annuus, Encelia farinosa, Bebbia juncea, Psilostrophe cooperi, Baileya multiradiata, Chaenactis fremontii, Pectis papposa, Haplopappus sp., Chrysothamnus sp., Baccharis sp., Senecio douglasii, Pluchea sericea, Cirsium sp., Taraxacum officinale (Asteraceae).

Vanessa annabella (Field).

Common to abundant in nearly all habitats. Lowland records are from early February to mid Décember and high elevation records are from early April to mid November. Desert records are for spring and fall.

SPECIMENS EXAMINED: (149) Specimens were seen for all months except January, August and December but there are sight records for the latter two months.

LARVAL FOODPLANTS: Sphaeralcea ambigua Gray (Malvaceae); many records (larvae). Althaea rosea (L.) Cav. (Malvaceae): Las Vegas, several records (ovip., larvae).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Lepidium fremontii, Erysimum asperum (Brassicaceae); Eriogonum fasciculatum (Polygonaceae); Abronia villosa (Nyctaginaceae); Apocynum androsaemifolium (Apocynaceae); Phacelia fremontii, Eriodictyon angustifolium (Hydrophyllaceae); Heliotropium curassavicum (Boraginaceae); Marrubium ·vulgare (Lamiaceae); Ribes aureum (Saxifragaceae); Medicago sativa, Melilotus albus (Fabaceae); Helianthus annuus, Encelia farinosa, Bebbia juncea, Baileya multiradiata, Chaenactis fremontii, Solidago spectabilis, Chrysothamnus sp., Baccharis sp., Cirsium sp., Taraxacum officinale (Asteraceae).

Precis coenia (Huebner).

Common in agricultural areas and relatively rare away from these occurring occasionally in desert washes, at springs and at high elevations. The flight period is from mid April to mid November. Most specimens are from agricultural areas from late August to mid November. Wild populations are irregular and suggest that the species is maintained in these areas by repeated immigrations.

SPECIMENS EXAMINED: (85) CC, 19 Apr. 75 (1 m, NSM), 18 May 78 (1 m), 26 June 78 (1 m); XM, 6 May 79 (1 m), 21 July 78 (1 m); WC, 22 June 78 (1 f), 13 Oct. 78 (1 m, 1 f); Cold Creek Ranger Station, 22 June 78 (1 m), 26 Oct. 77 (1 m); KC Ski Run, 24 June 79 (1 f); Cold Creek, 20 July 78 (1 m); GC, 21 Aug. 78 (1 m), 8 owman's Reservoir, 23 Aug. 77 (1 m), 29 Sept. 77 (1 m); LO, 23 Aug. 77 (1 m), 4 Sept. 77 (1 m), 17 Sept. 77 (1 m), 28 Sept. 67 (1 m, 2 f, NSM), 28 Sept. 68 (1 m, NSM), 29 Sept. 77 (1 m), 9 Oct. 77 (3 m, 3 f), 16 Oct. 77 (1 m); Clark Co., Sept. 73 (1, UNLV); OV, 4 Sept. 66 (3 m), 15 Sept. 63 (2 m, 1 f, NSM), 25 Sept. 66 (3 m), 27 Sept. 78 (1 m, NSM), 29 Sept. 66 (1 m, 1 f, NSM), 23 Oct. 77 (9 m, 4 f), 5 Nov. 77 (5 m, 6 f), 11 Nov. 77 (9 m, 2 f); 1 mi. W. MS, 30 Sept. 79 (3 m, 1 f); Hidden Valley, 9 Oct. 77 (1 m); Las Vegas, 12 Oct. 70 (1, UNLV); 1.8 mi. E. Blue Diamond, 22 Oct. 77 (1 f).

ADDITIONAL RECORDS: Other records for span of dates above. Additional locations are CP Rd., Pine Creek, RC area, Sawmill Canyon, RR and Tule Springs. ADULT RESOURCES: *Medicago sativa* (Fabaceae); *Baccharis* sp., *Tetradymia axillaris*, *Tetradymia canescens*, *Cirsium* sp. (Asteraceae).

Nymphalis californica (Boisduval).

Scattered records exist for this species above 6700' in the Spring and Sheep ranges. There is also one record for the Virgin Mts. In most years it is rare or absent but it was reported as "very abundant" in 1950 (FWP).

SPECIMENS EXAMINED: (6) CC, 5 June 79 (1, CSL); KC, 12 June 66 (1 m); Clark Canyon, 8000', 10 July 75 (1 f, NSM); Little Falls, 8000', 31 July 62 (2, JFL); KC, 78000', 11 Oct. 71 (1, JFL).

ADDITIONAL RECORDS: WC, 22 June 78 (s); Hidden Forest, 23 June 61 (KR); Little Falls, 29 June 63 (KR); KC, 6700-7500', 30 June 50 (FWP); KC Ski Run, 2 July 78 (s); Charleston Mts., 10-12 Aug. 63 (JFE).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae).

Nymphalis milberti furcillata (Say).

Rare in Kyle Canyon and the Cold-Willow creeks area and usually not far from its foodplant *Urtica holsericea* which grows in small patches at these localities. Records extend from late April to early July, probably reflecting a single brood emerging in late June and overwintering.

SPECIMENS EXAMINED: (3) WC, 27 Apr. 77 (1 m; 1, CSL), 4 July 62 (1 m).

ADDITIONAL RECORDS: Little Falls, 15 May 72 (JFL); WC, 22 June 68, 22 June 78 (s); Charleston Peak, 24 June 68 (JFE, OS).

LARVAL FOODPLANTS: Urtica holosericea Nutt. (Urticaceae): KC, 23 May 63 (larvae, JL).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae).

Nymphalis antiopa antiopa (Linnaeus).

Uncommon over a wide elevational range to at least 9000'. Low elevation records are generally from the vicinity of springs or towns. The flight period extends from early February to mid November. One brood is involved with overwintering adults occurring as late as 5 July and overlapping with the next generation which has been caught as early as 14 May.

SPECIMENS EXAMINED: (30) Willow Spring, 23 Mar. 77 (1 m, 1 f, NSM); Lost Creek, 23 Mar. 77 (1 f, NSM), 20 Apr. 77 (1 f, NSM); Pine Creek, 23 Mar. 77 (1 m, NSM), 9 Oct. 71 (1, UNLV); KC, 20 mi. W. U.S. 95, 26 Apr. 77 (2 m), 5 July 78 (1 m, 1 f), 6 July 77 (1 m); 2 mi. N. RC, 4 May 78 (1 f); Clark Co., 14 May 67 (1, UNLV), 9 Sept. 74 (1, UNLV); KC, 14 May 67 (1 f), 6 June 67 (1, UNLV); LO, 17 May 78 (1 f); WC, 25 May 78 (1 m), 22 June 78 (1 m), 23 June 62 (1 m), 1 July 77 (1 m), 14 Oct. 77 (1 f); WC, 30 May 66 (1 f), 23 June 62 (1 m); RD Summit Rd., 2.1 mi. E. Lovell Wash, 22 June 77 (1 m); KC Campground, 24 June 79 (1 m); KC, 3340′, 5 July 65 (1 m); Little Falls, 20 July 65 (1 m); Las Vegas, 18 Oct. 76 (1, UNLV); Tule Springs, 4 Nov. 77 (1 f).

ADDITIONAL RECORDS: Records for all months from 8 Feb. (70, Las Vegas, in desert area, s) to 18 Nov. (79, Las Vegas, s) mostly for locations cited above. There are also records for the Sheep, Newberry and Virgin mountains.

Polygonia satyrus satyrus (Edwards).

Less widespread than *P. zephyrus* reflecting the local distribution of its probable foodplant, *Urtica holosericea*. The 2 broods fly from June to August and in October. The latter brood overwinters and flies again in March and April. The overwintering brood is darker brown and more yellowish beneath than the summer brood.

SPECIMENS EXAMINED: (29) Lost Creek, 23 Mar. 77 (1 m, CSL); WC, 27 Apr. 77 (1 m, 1 f), 5 June 79 (1 m, 2 f), 11 June 79 (1 m, 1 f), 22 June 68 (1 m), 22 June 78 (2 f), 1 July 77 (4 m), 20 July 77 (2 m, 2 f), 20 July 78 (1 m), 8 Aug. 71 (1 f), 13 Oct. 78 (1 m); KC, 20 mi. W. U.S. 95, 14 June 77 (1 f); KC Campground, 24 June 79 (1 m); WC, 1 July 77 (1 m), 14 Oct. 77 (1 m), 26 Oct. 77 (2 m); Deer Creek, 21 Aug. 71 (1, UNLV).

ADDITIONAL RECORDS: WC, 13 June 77, 22 June 78 (s), 29 June 63 (KR), 28 July 77 (s); Little Falls, 22 June 62, 26 June 63, 4 July 72, 5 July 62 (JFL); KC, 9500', 1 July 72 (JFL); Clark Canyon, 10 July 75 (CSL); Charleston Mts., 31 July 65 (RES); Mack's Canyon, 28 Aug. 75 (CSL).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Penstamon palmeri (Scrophulariaceae); Marrubium vulgare (Lamiaceae); Melilotus albus (Fabaceae); Salix lasiolepis (Salicaceae); Chrysothamnus sp. (Asteraceae).

Polygonia zephyrus (Edwards).

Locally common above 6000' to as high as 11,200'. It flies in 2 broods, the largest numbers appearing in September and October representing the overwintering population which again flies in March and April. A summer brood flies from late May to August. The latter consists of larger individuals which are more yellow-orange above and browner beneath than the fall brood.

SPECIMENS EXAMINED: (65) KC, 17.1-20.0 mi. W. U.S. 95, 22 Mar. 77 (2 m), 28 June 78 (1 m), 25 Aug. 78 (1 m), 26 Sept. 77 (1 m, 2 f), 27 Sept. 78 (4 m, 3 f), 3 Oct. 77 (1 f), 12 Oct. 77 (1 m); Willow Spring, 26 Mar. 78 (1 f, CSL); Deer Creek, 31 May 77 (1 m); WC, 22 June 78 (1 m); Deer Creek Rd., 2.8 mi. N. KC, 24 June 79 (1 m), 26 June 79 (1 f); KC Campground, 24 June 79 (1 m), 8 Oct. 77 (1 m); KC Ski Run, 26 June 79 (1 m), 10 July 79 (2 m), 12 July 78 (1 m), 20 July 65 (1 m), 27 Sept. 78 (4 m), 28 Sept. 77 (4 f), 8 Oct. 77 (2 m); KC, 8000-9000′, 5 July 65 (2 m, 1 f), 13 July 69 (1 m), 25 July 65 (1 f); LC, 8000-9000′, 5 July 76 (1 m, 1 f, DM), 29 July 77 (1 m); Little Falls, 13 July 65 (1 f), 20 July 65 (1 m, 1 f); ridge above KC, 11,200′, 15 July 79 (1 m), 19 July 78 (1 m, 3 f); Echo Canyon, 28 Sept. 77 (1 m, 2 f), 8 Oct. 77 (3 m), 23 Oct. 66 (1 m); KC, 9 Oct. 66 (3 m); RD, 15 Oct. 73 (1 f, UNLV).

ADDITIONAL RECORDS: KC Ski Run, 24 June 79, 18 July 79 (s); Little Falls, 29 June 63 (KR), 8 Aug. 62 (JFL); KC, 1 July 72 (JFL), 8 Aug. 74 (JAS), 26 Sept. 65 (PJH); Deer Creek Rd., 2.8 mi. N. KC, 10 July 79 (s); Cathedral Rock, 13 July 72 (DEA); Charleston Peak Trail, 11,200′, 14 July 77 (s); LC, 8 Aug. 74 (JAS), 17 Aug. 63 (JFL), 23 Sept. 75 (s); Charleston Mts., 10-12 Aug. 63 (JFE); Echo Canyon, 9 Oct. 66, 15 Oct. 77 (s).

LARVAL FOODPLANTS: Ribes cereum Dougl. (Saxifragaceae): KC, 31 Aug. 67 (larvae, Shields et al. 1969); ridge above KC, 11,200', 19 July 78 (ovip., 2x, on main stem at base of branch, 12:00 PST; plant adjacent to snowbank, leaves unopened).

ADULT RESOURCES: Chrysothamnus sp. (Asteraceae).

Chlosyne palla vallismortis (Johnson).

Not common in Kyle Canyon between 6700' and 8000'. Records are for mid May and mid June to mid July. The flight season appears to be very short in some years. I took specimens on 5 and 7 July 1977 but none were seen by me on 17 June or 15 July in the same area. Lawson did not see it on 30 June and Mullins took it on 2 July. In 1965, however, specimens were taken over a 5 week period.

We tentatively assign the Spring Range population to *vallismortis* of the Panamint Mountains of California. The populations are similar in their large size although that of the Spring Range is slightly redder in color.

SPECIMENS EXAMINED: (85) Charleston Mts., 14 May 34 (10 m, 1 f, LACM); WC, 11 June 79 (1 m); KC, 6800', 13 June 65 (1 m); KC Campground, 20 June 79 (17 m), 24 June 79 (15 m, 1 f), 26 June 79 (9 m, 2 f), 5 July 77 (9 m), 7 July 77 (5 m, 1 f), 20 July 65 (1 m); 1 mi. N. KC on Deer Creek Rd., 2 July 77 (6 m, 2 f, DM); Deer Creek, 11 July 65 (1 m); KC, 7500', 15 July 74 (1 m, 2 f).

ADDITIONAL RECORDS: KC, 6768', 30 June 50 (FWP); KC, 6770', 1 July 50 (Howe 1975); between KC and Deer Creek, 7000', 1 July 50 (FWP); KC, 8000', 5 July 65 (s).

ADULT RESOURCES: Viguiera multiflora (Asteraceae).

Chlosyne neumoegeni neumoegeni (Skinner).

Common to abundant, mostly in desert washes, to 5000'. The flight period involves a large spring brood from early March (one January and two February records) to mid May with a peak in mid April and an irregular and sometimes absent (depending on rainfall) fall brood from early September to early November. Some colonies may occasionally produce a small second spring brood (1978, Newberry Mountains).

SPECIMENS EXAMINED: (422) Specimens or other records are for the dates

from 3 Mar. (63, RR, s) to 7 June (78, CC, s) and 3 Sept. (61, Blue Diamond, KR) to 2 Nov. (77, 1.8 mi. E. Blue Diamond, 2 f). There are records for 21 Jan. 64, 6 Feb. 77 and 8 Feb. 70.

LARVAL FOODPLANTS: Acamptopappus shockleyi Gray (Asteraceae): 0.5 mi. S. Red Spring, 27 Apr. 79 (ovip. on flower buds, 09:15 PST); 12 mi. N. I-15 on U.S. 93, 15 May 77 (larvae on disc flowers). Macaeranthera tortifolia (Gray) Cronq. & Keck (Asteraceae); XM, 22 Apr. 79 (ovip. lower surface of lower leaves near center of plant, 10:30 PST); 0.5 mi. S. Red Spring, 21 Apr. 79 (larvae); 9 mi. W. Davis Dam, 3 May 78 (small larvae on disc flowers); XM, 12 May 78 (larvae mostly on disc flowers, also feeding on ray flowers after disc consumed); 12 mi. N. I-15 on U.S. 93, 15 May 77 (larvae on disc flowers).

ADULT RESOURCES: Eriogonum fasciculatum (Polygonaceae); Menodora spinescens (Oleaceae); Cryptantha sp., Amsinckia tessellata (Boraginaceae); Lycium andersonii (Solanaceae); Encelia farinosa, Bebbia juncea, Baileya multiradiata, Baileya pleniradiata, Perityle emoryi, Eriophyllum wallacei, Chaenactis fremontii, Pectis papposa, Haplopappus sp., Acamptopappus shockleyi, Dyssodia cooperi, Chrysothamnus sp., Baccharis sp., Senecio douglasii (Asteraceae).

Chlosyne lacinia crocale (Edwards).

Common to abundant in agricultural areas of the Las Vegas and Moapa valleys; very rare elsewhere with records for Virgin Valley, Corn Creek and Grapevine Canyon. The flight period extends from mid April to late October involving 2-4 broods depending on availability of the larval foodplant, largely *Helianthus annuus*. The latter grows commonly along edges of fields and may be cut or burned at times depending on the particular farmer's practices.

All three forms occur in Clark County with the form "rufescens" predominating, comprising 70% of the population and forms "crocale" and "nigrescens" with 26% and 4%, respectively.

SPECIMENS EXAMINED: (342) Numerous records from Moapa and Las Vegas valleys between 13 Apr. (78) and 23 Oct. (77). Records away from here are Mesquite, 13 Apr. 78 (s), 18 Sept. 72 (1 f, NSM); Bunkerville, 17 May 78 (1 m, NSM); GC, 21 Aug. 78 (1 f), 27 Sept. 77 (s); CN, 7 Oct. 77 (1 m).

LARVAL FOODPLANTS: Helianthus annuus L. (Asteraceae): Hidden Valley, 23 Aug. 77, 29 Sept. 77 (many larvae). Xanthium strumarium L. (Asteraceae): MF, 13 Sept. 77 (many larvae).

ADULT RESOURCES: Tamarix pentandra (Tamaricaceae); Polygonum lapathifolium (Polygonaceae); Convolvulus sp. (Convolvulaceae); Heliotropium curassavicum (Boraginaceae); Medicago sativa (Fabaceae); Viguiera deltoidea, Helianthus annuus, Baileya pleniradiata, Baileya multiradiata, Baccharis sp., Pluchea sericea (Asteraceae).

Chlosyne californica (Wright).

Locally common in some years in the Newberry Mountains; rare elsewhere occurring as far north as Willow Creek in the Spring Range. It flies in 2 broods from mid March to early June and early September to late October. The timing and size of the second brood may depend on summer rainfall.

SPECIMENS EXAMINED: (167) GC, 23 Mar. 78 (2 m, NSM; 4 f), 8 Apr. 77 (1 m), 12 Apr. 78 (3 m, 1 f, NSM; 9 m, 3 f), 15 Apr. 78 (3 m, 5 f), 20 Apr. 78 (1 f, NSM; 1 m, 1 f), 3 May 78 (1 f), 5 May 77 (1 f, NSM; 2 m, 2 f), 12 May 78 (1 f), 1 June 78 (2 f, NSM), 26 Sept. 78 (1 m, 2 f, NSM; 1 m), 27 Sept. 77 (27 m, 22 f), 4 Oct. 77 (4 m, 6 f),

12 Oct. 77 (2 f), 25 Oct. 77 (1 f); MM, 12 Apr. 69 (2 m, NSM), 26 Sept. 68 (1 f, UNLV); XM, 15 Apr. 78 (1 m, 1 f), 22 Apr. 79 (10 m, 3 f), 3 May 78 (1 f), 6 May 79 (2 m, 5 f), 23 May 78 (1 m), 1 June 78 (2 m, NSM), 27 Sept. 77 (3 m, 1 f); 9 mi. W. Davis Dam, 15 Apr. 78 (1 f), 20 Apr. 78 (2 f, NSM), 12 May 78 (1 m), 23 May 78 (1 m); Sacatone Wash, 15 Apr. 78 (1 m, 2 f); 1 mi. W. Nipton Pass, 4 May 78 (2 m); Bridge Canyon, 12 May 78 (1 f), 26 Sept. 78 (1 m, NSM); 2 mi. N. RC, 27 May 78 (2 f); CP Rd., 1.5 mi. S. Pahrump Rd., 28 May 78 (1 f); Crescent Peak, 21 Sept. 72 (3 m, 5 f, NSM); 2.8 mi. E. Nelson, 27 Sept. 77 (1 m), 25 Oct. 77 (1 f).

ADDITIONAL RECORDS: XM, 18 Mar. 72 (JFL), 12 Apr. 78, 20 Apr. 78, 5 May 77, 12 May 78, 4 Oct. 77 (s); 9 mi. W. Davis Dam, 12 Apr. 78, 22 Apr. 79, 3 May 78 (s); Bridge Canyon, 3 May 78 (s); CP Rd., 0.6 mi. S. Pahrump Rd., 19 May 78 (s); WC, 6 June 78 (s); Ash Spring, 30 June 69 (JFE, OS); Blue Diamond, 3 Sept. 61 (KR); 0.5 mi. E. Boulder City, 3 Oct. 77 (s).

LARVAL FOODPLANTS: Viguiera deltoidea Gray (Asteraceae): GC, 14 Sept. 77 (larvae, skeletonizing leaves).

ADULT RESOURCES: Eriogonum fasciculatum (Polygonaceae); Amsinckia tessellata (Boraginaceae); Salvia sp. (Lamiaceae); Viguiera deltoidea, Encelia farinosa, Bebbia juncea, Perityle emoryi, Eriophyllum wallacei, Chaenactis fremontii, Haplopappus sp., Baccharis sp., Senecio douglasii, Pluchea sericea (Asteraceae).

Phyciodes texana texana (Edwards).

The only Nevada records are for Grapevine Canyon in April and Cabin Canyon in May.

SPECIMENS EXAMINED: (2) GC, 12 Apr. 78 (1 m), 20 Apr. 78 (1 m). ADDITIONAL RECORDS: GC, 15 Apr. 78 (s); CC, 20 May 79 (s).

Phyciodes tharos (Drury) ssp.

The only Nevada record is from Corn Creek. They belong to the unnamed southwestern United States-northwestern Mexico population. This taxon was called distincta by Bauer in Howe (1975). No type was, however, designated. Thus P. tharos distincta is a nomen nudum. The specimens are identical with material from Imperial Co., California.

SPECIMENS EXAMINED: (2) CN, 9 Sept. 64 (2 m, NSM).

ADDITIONAL RECORDS: None.

Phyciodes phaon (Edwards).

Very rare with records from mid September to early November for the Las Vegas area.

SPECIMENS EXAMINED: (9) Las Vegas, Sept. 75 (1 m, ex UNLV), 16 Sept. 77 (1, UNLV), Oct. 75 (1 m, ex UNLV), 8 Oct. 77 (1 f, UNLV), 13 Oct. 76 (1 f), 13 Oct. 77 (1 m, UNLV), 15 Oct. 78 (1 f), 7 Nov. 77 (1 f, UNLV); Clark Co., 1 Oct. 76 (1 f, ex UNLV).

ADDITIONAL RECORDS: None.

Phyciodes pallida barnesi Skinner.

A single specimen for this taxon exists for Clark County. Populations are known for adjacent Lincoln Co., Nevada, (GTA) and Washington Co., Utah (Tidwell and Callaghan 1972).

SPECIMENS EXAMINED: (1) CN, 15 July 64 (1 m, NSM).

ADDITIONAL RECORDS: None.

Phyciodes mylitta mylitta (Edwards).

A single specimen from Kyle Canyon referrable to the nominate race was examined. Another record from the same area is the only other one known from the county. These may represent a small breeding colony as its known foodplant, *Cirsium*, is quite common here.

SPECIMENS EXAMINED: (1) Charleston Park, 30 June 77 (1 f, CSL). ADDITIONAL RECORDS: Charleston Park, 29 June 63 (KR).

Thessalia leanira alma (Strecker).

Uncommon locally at middle elevations between 3400' and 6100' especially in the southern portion of the Spring Range in the Cottonwood Pass area. Records extend from mid April to mid May and a fresh individual seen on 13 June.

SPECIMENS EXAMINED: (184) Blue Diamond, 12 Apr. 69 (1 m, NSM); CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 16 Apr. 77 (3 m, 2 f), 16 Apr. 79 (1 m), 20 Apr. 77 (4 m), 22 Apr. 78 (6 m), 29 Apr. 78 (1 m), 29 Apr. 79 (26 m, 13 f), 2 May 77 (2 m), 2 May 78 (7 m, 2 f), 3 May 78 (3 m, 1 f, NSM), 6 May 78 (1 m, NSM), 11 May 78 (4 m, 2 f), 13 May 79 (4 m), 19 May 78 (3 m); 3 mi. W. Blue Diamond, 20 Apr. 77 (2 m, 5 f); 0.5 mi. S. Red Spring, 21 Apr. 79 (17 m, 2 f), 29 Apr. 79 (30 m, 4 f), 2 mi. E. MS, 24 Apr. 77 (1 m, 1 f); WC, 27 Apr. 77 (1 m, NSM), 29 Apr. 77 (1 m, NSM); CC, 27 Apr. 78 (1 m), 10 May 78 (1 m); Pine Creek, 2 May 77 (1 m); KC, 6.6 mi. W. U.S. 95, 2 May 77 (1 f), 2 May 78 (4 m), 11 May 78 (3 m); 1 mi. W. WC, 8 May 78 (1 m), 25 May 78 (2 m); KC, 9.3 mi. W. U.S. 95, 13 May 78 (1 m); 0.5 mi. E. MS, 13 May 79 (12 m), 19 May 78 (3 m); 1.5 mi. E. MS, 13 May 79 (1 m); RC, 27 May 78 (2 m); Wilson Pass, ex larva emerged 21 Apr. 78 (1 f).

ADDITIONAL RECORDS: White Rock Spring, 2 May 78 (s); RC, 4 May 78, 27 May 78 (s); 2 mi. N. RC, 4 May 78, 27 May 78 (s), WC, 13 June 77 (s).

LARVAL FOODPLANTS: Castilleja chromosa A. Nels. (Scrophulariaceae): RD Canyon, 25-27 Mar. 75 (larvae, JB); Willow Spring, 29 Mar. 78 (larvae feeding on flowers and leaves); Wilson Pass, 29 Mar. 78 (larvae feeding on flowers).

ADULT RESOURCES: Menodora spinescens (Oleaceae); Baileya multiradiata, Eriophyllum wallacei, Chaenactis fremontii, Acamptopappus shockleyi, Senecio douglasii, Senecio multilobatus (Asteraceae).

Poladryas minuta arachne (Edwards).

Common very locally on the west slope of the Spring Range at elevations of  $4500^{\circ}$  to  $6000^{\circ}$ . The flight periods of the 2 broads are late April to late June and early September to mid October.

Southern Nevada material with its two-toned orange ground color is clearly within the concept of *P. m. arachne*, especially like northern Arizona populations. In comparison with a series from Flagstaff, Coconino Co., Arizona, southern Nevada material differs in having slightly less black on the basal half of both wings above and below, the ground color of the primaries below is more even (less two-toned) and the light areas of the secondaries below are less creamy. In fact, these light areas are the whitest of all populations of *minuta* examined except those of southern Arizona, *P. m. gilensis* (Holland), to which southern Nevada specimens are comparable in this aspect. The use of the specific name *minuta* is based on the studies of Scott (1974).

SPECIMENS EXAMINED: (51) CP Rd., 0.6-1.8 mi. S. Pahrump Rd., 29 Apr. 78 (1 m), 2 May 78 (3 m), 3 May 78 (3 m, NSM), 11 May 78 (2 m), 13 May 79 (1 m), 28 May 78 (1 m); 0.5 mi. E. MS, 13 May 79 (12 m), 19 May 78 (3 m); CC, 20 May 78 (1 f); 5 June 79 (1 f, CSL); Trout Canyon Ranch, 14 June 77 (6 m), 18 Sept. 77 (1 m);

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6.1 mi. N. Spring Mountain Youth Camp, rd. to Trout Canyon, 14 June 77 (1 m); RD Summit Rd., 1.5 mi. E. Lovell Wash, 22 June 77 (1 f); MS, 6 Sept. 69 (2 f, NSM); 1 mi. W. MS, 28 Sept. 78 (1 m), 1 Oct. 77 (9 m, 1 f), 11 Oct. 77 (1 f).

ADDITIONAL RECORDS: 1 mi. W. WC, 8 May 78 (s); 1:5 mi. E. MS, 13 May 79 (s).

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); Viguiera multiflora, Erigeron sp. (Asteraceae).

Euphydryas chalcedona kingstonensis Emmel & Emmel.

One desert population of this species is known in the Newberry Mountains. It flies in a large spring brood from mid March to early June and a small brood depending on summer rains in September. Specimens are within the range of variation of southern California populations.

SPECIMENS EXAMINED: (269) GC, 8 Apr. 77 (1 f, CSL; 1 m, 1 f), 12 Apr. 78 (1 m, NSM), 15 Apr. 78 (2 m), 20 Apr. 78 (5 m, NSM; 12 m, 1 f), 3 May 78 (21 m, 2 f), 12 May 78 (10 m, 5 f), 23 May 78 (1 m), 1 June 78 (1 m, 1 f, NSM), 14 Sept. 77 (3 m, 5 f); XM, 12 Apr. 78 (6 m, NSM; 13 m), 15 Apr. 78 (4 m, 1 f), 20 Apr. 78 (12 m, 3 f), 22 Apr. 79 (35 m, 2 f), 3 May 78 (13 m, 3 f), 5 May 77 (1 m, CSL), 6 May 79 (49 m, 26 f), 12 May 78 (11 m, 13 f), 23 May 78 (4 m).

ADDITIONAL RECORDS: XM, 18 Mar. 72 (JFL), 1 June 78, 19 Aug. 79 (s); GC, 23 Mar. 78 (CSL, s), 27 Sept. 77 (s); Sacatone Wash, 15 Apr. 78 (s).

LARVAL FOODPLANTS: Keckiella antirrhinoides Benth. ssp. microphyllus (Gray) Keck (Scrophulariaceae): XM, 12 Apr. 78 (last instar larvae feeding on leaves).

ADULT RESOURCES: Eriogonum fasciculatum (Polygonaceae); Amsonia tomentosa (Apocynaceae); Phacelia fremontii, Phacelia vallis-mortae, (Hydrophyllaceae); Amsinckia tessellata (Boraginaceae); Salvia sp. (Lamiaceae); Baileya multiradiata, Senecio douglasii (Asteraceae).

Euphydryas anicia morandi Gunder.

This distinctive taxon is locally common in the Spring Range especially in the meadows on the ridge to Charleston Peak and above the ski area in Lee Canyon. Most records are for above 10,000' although it is occasionally taken as low as 6800'. The flight period of the single brood is usually from late June to mid July; a number of early (1940 and before) collections, however, were made in early May to early June.

SPECIMENS EXAMINED: (168) Charleston Mts., 7 May 29 (1 f, LACM), 13 May 34 (1 m, LACM), 14 May 34 (17 m, 1 f, LACM), 19 May 34 (2 m, LACM); Mt. Charleston, 1 June 33 (4 m, LACM); KC Campground, 30 June 77 (1 m, CSL); LC above ski area, 2 July 77 (6 m, 1 f, DM), 5 July 76 (6 m, 6 f, NSM), 6 July 66 (8 m, 7 f, DM); Charleston Peak trail above KC, 10,400-11,300′, 14 July 77 (27 m, 5 f), 15 July 79 (43 m, 14 f), 19 July 78 (10 m, 8 f).

ADDITIONAL RECORDS: Mt. Charleston, 7 May 29 (DE), 10 May 36 (DE), 10 May 40 (DE), 26 June 36 (DE); trail to Charleston Peak, 10,800-11,500', (TCE, OS); Mt. Charleston, 10,500-11,360', (JFL); KC, 10,500-11,000', 10-16 July 28 (type series, Gunder 1928).

ADULT RESOURCES: Erysimum asperum (Brassicaceae); Taraxacum officinale (Asteraceae).

Euphydryas anicia (Doubleday) ssp.

A population which does not seem to fit any described subspecies of anicia flies in

the Virgin Mountains between 4000' and 5000' in April and May. Its relationships appear towards Rocky Mountain populations.

SPECIMENS EXAMINED: (17) CC, 8 Apr. 79 (1 m, 1 f), 13 Apr. 74 (1 m, NSM), 14 Apr. 77 (2 m, 1 f, CSL), 27 Apr. 78 (2 m), 10 May 78 (1 m), 18 May 78 (1 m), 20 May 78 (1 m), 20 May 79 (6 m).

ADDITIONAL RECORDS: None.

Speyeria zerene carolae (dos Passos & Grey).

This endemic is locally common on the east slope of the Spring Range from 6700' to 10,800', but mostly below 7500' in Kyle Canyon. There is but one west slope record for the low elevation of 5000' in Lovell Wash. The flight period for the single brood is from mid June to early September with a peak in mid to late July. Very late records are in late September and mid October.

SPECIMENS EXAMINED: (179) Numerous records with the earliest date on 17 June (66, LC and Deer Creek, s). Latest record is 11 Oct. (77, KC Campground, s). The only record away from the east slope is Lovell Wash, 5000', 17 June 62 (s).

ADULT RESOURCES: Erysimum asperum (Brassicaceae); Apocynum androsaemifolium (Apocynaceae); Rosa woodsii (Rosaceae); Lupinus sp. (Fabaceae); Angelica scabrida (Apiaceae); Chaenactis sp., Cirsium sp. (Asteraceae).

Euptoieta claudia (Cramer).

Very rare with four known records for the county.

SPECIMENS EXAMINED: (3) Ash Springs, 3800', 19 Mar. 72 (1, JFL); CN, 22 June 68 (2, JFL).

ADDITIONAL RECORDS: Sawmill Canyon, 1 July 69 (1969 summ.); 1 mi. N. CP, 23 Aug. 75 (JB).

## Family Heliconiidae

Agraulis vanillae incarnata (Riley).

The only state records are a stray caught in the authors' yard in Las Vegas and two sight records.

SPECIMENS EXAMINED: (1) Las Vegas, 19 June 68 (1 f).

ADDITIONAL RECORDS: 0.5 mi. N. Red Spring, 29 Apr. 79 (s); XM, 6 May 79 (s).

# Family Danaidae

Danaus plexippus plexippus (Linnaeus).

Not uncommon especially in mesic canyons, near springs and, after July, at the higher elevations. Records are for every month except January but it is most abundant from mid June to mid November. There are many Las Vegas records from August to November and a few desert records in early spring and fall. High elevation records are from early July to mid November. A concentration of about 40 individuals was at Tule Springs on 6 Sept. 75 and over 200 were seen in Pine Creek on 5 Oct. 77.

SPECIMENS EXAMINED: (124) Records from numerous locations throughout the county between 6 Feb. (77, 1.5 mi. S. Davis Dam, s) to 25 Dec. (65, CN, s).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Stanleya pinnata (Brassicaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Marrubium vulgare (Lamiaceae); Cowania mexicana (Rosaceae); Medicago sativa, Melilotus albus (Fabaceae); Angelica scabrida (Apiaceae); Viguiera deltoidea, Helianthus annuus, Solidago spectabilis, Chrysothamnus sp., Baccharis sp., Senecio douglasii, Cirsium sp. (Asteraceae).

Danaus gilippus strigosus (Bates).

Locally common in certain low canyons (Pine Creek, Grapevine Canyon) but found in most areas of the county to at least 8500'. There are records for every month except March but most records are from mid June to early November.

SPECIMENS EXAMINED: (229) Numerous records through most of the year from many locations; desert records are few. High elevation records are from 25 May (78, WC, s) to 22 Aug. (77, KC Ski Run, s).

LARVAL FOODPLANTS: Sarcostemma hirtellum (Gray) R. Holm (Asclepiadaceae): GC, 20 Apr. 78 (ovip. on stems, 13:30 PST), 3 Aug. 77 (mature larva), 27 Sept. 77 (ovip. single eggs on stems between leaf bases, 10:40 PST, 11:00 PST). Asclepias subulata Dcne. in A. DC. (Asclepiadaceae): 9 mi. W. Davis Dam, 3 May 78 (ovip. beneath flower heads, 10:00 PST).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Tamarix pentandra (Tamaricaceae); Eriogonum fasciculatum (Polygonaceae); Apocynum androsaemifolium (Apocynaceae); Sarcostemma hirtellum (Asclepiadaceae); Eriodictyon angustifolium (Hydrophyllaceae); Acacia greggii, Prosopis glandulosa, Prosopis pubescens, Melilotus albus (Fabaceae); Viguiera deltoidea, Helianthus annuus, Bebbia juncea, Solidago spectabilis, Chrysothamnus sp., Baccharis sp., Senecio douglasii, Tetradymia canescens, Pluchea sericea, Cirsium sp. (Asteraceae).

## Family Satyridae

Cyllopsis pertepida dorothea (Nabokov).

The population in the Virgin Mountains is the only known colony for the state except for one in Meadow Valley Wash in Lincoln Co. (1968 summ.). It flies in 2 broads from late May to late June and in September and October. The taxonomy follows Miller (1974).

SPECIMENS EXAMINED: (23) CC, 29 May 78 (3 m), 7 June 78 (2 f, NSM; 2 m), 8 June 78 (1 m, 1 f), 26 June 78 (5 m, 4 f), 12 Sept. 74 (2 m, NSM), 20 Sept. 72 (1 f, NSM), 11 Oct. 78 (2 m).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Eriodictyon angustifolium (Hydrophyllaceae); occasionally visit water.

Coenonympha california california Westwood.

A single specimen from the Spring Range is the only southern Nevada record. SPECIMENS EXAMINED: (1) WC, 22 June 78 (1 m).

ADDITIONAL RECORDS: None.

ADULT RESOURCES: Rorippa nasturtium-aquaticum (Brassicaceae).

Coenonympha ochracea brenda Edwards.

Uncommon in the Spring Range above 6500' but mostly above 7500' in open areas. The single brood usually flies from mid June to early August although there are May records.

Spring Range material along with certain other Nevada material (White Pine, Nye, Lander counties) fall within the concept of Utah *brenda* although there are minor differences in pattern (see also Brown 1964).

SPECIMENS EXAMINED: (48) Charleston Mts., 12 May 34 (7 m, 5 f, LACM); KC, 8000', 12 June 66 (1 m), 5 July 65 (4 m, 2 f); above Cathedral Rock Campground, 17 June 77 (3 m, 1 f); KC Campground, 22 June 78 (1 m); KC Ski Run, 24 June 79 (1 f), 5 July 77 (1 m); KC, 7680', 27 June 65 (1 m); Clark Canyon, 2

July 75 (1 m, NSM); Deer Creek, 11 July 65 (2 m); Little Falls, 13 July 65 (1 m, 1 f); Charleston Peak trail, 10,900-11,300', 14 July 77 (1 m, 1 f), 15 July 79 (1 m), 19 July 78 (4 m, 3 f); KC, 9000', 25 July 65 (1 m), 26 July 64 (1 m), 27 July 66 (1 m, 2 f); LC, 8700', 26 July 65 (1 m).

ADDITIONAL RECORDS: Charleston Mts., 14 May 34 (CDF), 6 Aug. 61 (RES); KC, 7100′, 11 June 65, 17 June 66 (s); LC, 17 June 66 (s); KC Campground, 21 June 66, 13 July 65 (s); KC, 7600′, 22 June 63, 26 June 63, 29 June 63, 5 July 62 (JFL); KC Ski Run, 22 June 78 (s); KC, 10,000-10,500′, 24 June 68 (JFE, OS); KC, 20 mi. W. U.S. 95, 28 June 77, 6 July 77 (s); Little Falls, 29 June 63 (KR), 4 July 72 (JFL); KC, 10,500-11,200′, 1 July 72 (JFL); Deer Creek Rd., 7000′, 1 July 50 (FWP); Charleston Peak trail, 9000′, 14 July 77 (s).

ADULT RESOURCES: Lupinus sp. (Fabaceae); Senecio multilobatus (Asteraceae).

Cercyonis sthenele (Boisduval) ssp.

Locally common mostly above 5000' but occasionally as low as 3300' on sagebrush flats or in chaparral vegetation. The single brood flies from mid June through late August.

All Nevada material was referred to previously by Emmel (1969) as *C. s. paulus* (Edwards). Clark County material and that of adjacent areas do not have the extensive white overscaling beneath as is typical of *paulus* and resemble certain material from the desert mountains of southern California. These populations most closely resemble the Rocky Mountain *C. s. masoni* Cross but probably are distinct and deserve to be named.

SPECIMENS EXAMINED: (60) KC, 15 mi. W. U.S. 95, 20 June 79 (1 m); WC, 22 June 78 (1 f), 20 July 77 (1 m, 3 f), 28 July 77 (1 m, 1 f); WC, 1 July 77 (2 m), 4 July 62 (1 m, 1 f), 20 July 78 (1 m, 2 f), 28 July 77 (2 m, 8 f); KC, 3340′, 5 July 65 (3 m); KC, 5680′, 5 July 65 (1 m), 18 July 65 (5 m); Lovell Wash, 6100′, 14 July 62 (2 m, 1 f); KC Campground, 15 July 77 (5 m), 25 July 77 (3 m); KC, 17.1 mi. W. U.S. 95, 15 July 77 (2 m, 2 f); Lovell Wash, 18 July 62 (1 f); Cold Creek Ranger Station, 20 July 77 (2 m, 1 f); RD Summit Rd., 1.5-2.1 mi. E. Lovell Wash, 27 July 77 (3 m, 4 f).

ADDITIONAL RECORDS: KC Campground, 20 June 79, 25 July 65, 1 Aug. 77 (s); RD Summit Rd., 1.5 mi. E. Lovell Wash, 22 June 77 (s); CC, 26 June 78, (s); KC, 14.5 mi. W. U.S. 95, 28 June 77, 27 July 77 (s); KC Ranger Station, 29 June 63 (KR); WC, 29 June 63 (KR); KC, 6770′, 30 June 50 (FWP); MS, 30 June 63 (KR), 30 June 69 (JFE, OS); Deer Creek Rd., 1 July 50 (FWP); mouth Sawmill Canyon, 1 July 69 (JFE, OS); Mt. Charleston, 9 July 74 (CDF); LC, 9 July 74 (CDF); Lovell Wash, 10 July 75 (CSL); KC, 17.1 mi. W. U.S. 95, 11 July 77 (s); WC, 20 July 78, 5 Aug. 77 (s); KC, 6800′, 18 July 65 (s); KC, 14 mi. W. U.S. 95, 25 July 65 (s); Charleston Mts., 31 July 65 (JL, RES); KC, 7400′, 12 Aug. 63, 18 Aug. 63 (JFL); lower KC, 24 Aug. 75 (JB).

ADULT RESOURCES: Clematis ligusticifolia (Ranunculaceae); Eriodictyon angustifolium (Hydrophyllaceae); Tetradymia canescens, Cirsium sp. (Asteraceae).

#### **Dubious Records**

At least five species have been attributed to the Clark County butterfly fauna based on misidentifications or poor knowledge of their distribution.

Amblyscirtes eos (Edwards).

The record for this species (1972 summ.) refers to *Pholisora alpheus* (fide JFL). This species should be deleted from the state list.

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Ochlodes sylvanoides (Boisduval).

Herlan reported to us that a pair of this species was taken in the Overton area on 29 Sept. 66 and one of these was indicated in the Nevada State Museum catalogue. This specimen was located and proved to be a male *Polites sabuleti*. Ochlodes sylvanoides is thus apparently unknown in Clark County although it is common farther north in the state.

Ochlodes agricola (Boisduval).

Herlan reported to us that three males were taken at Warm Springs (Moapa Valley) on 27 Oct. 65 and these were listed in the Nevada State Museum catalogue. These specimens could not be located in the museum. We thus consider this species to be of hypothetical occurrence in Clark County.

Hesperia uncas lasus (Edwards).

This species was reported by Herlan (1972 summ.) for Crescent Peak in the McGullough Range.

A search of the collection at the Nevada State Museum failed to produce a specimen. No specimens are listed in their catalogue from Clark County. The species must thus be considered of hypothetical occurrence in Clark County.

Polites sonora sonora (Scudder).

The taxon is included as hypothetical based on the range "to southern Nevada" by Howe (1975). We know of no southern Nevada records although the species is regular in northern Nevada.

### **Faunal Composition**

Clark County's butterfly fauna totals 125 taxa of 118 species. Of these, one species appears to have become locally extinct (L. dorcas), if it ever occurred, and at least 15 are considered non-breeding strays (A. python, H. domicilla, C. asychis, T. pylades, P. leo, C. philodice, P. sennae, E. mexicana, L. bachmanii, P. texana, P. tharos, P. pallida, E. claudia, A. vanillae and C. california). We doubt that more than 10 to 15 species will be added to the county list in future years. It is unlikely that many new resident species will be found although such species as Erynnis afranius (Lintner) and Hypaurotis crysalus (Edwards) are possibilities in the Virgin Mountains.

The 125 taxa belong to 11 families with Lycaenidae, Nymphalidae and Hesperidae being the most important comprising over 70% of the total fauna (Table 1). Similar species composition occurs in other areas of western North America (e.g., Brown et at. 1957, Emmel and Emmel 1963, Opler and Langston 1968, Tidwell and Callaghan 1972).

To further consider the distribution of butterflies in Clark County, four major habitat groupings were delineated. Desert scrub occurs at low elevations generally below 4000-5000' and includes high water table associations of mesquite. Riparian and agricultural habitat includes vegetation which requires a nearly constant water supply whether it be natural along streams or artificial as urban or cultivated areas. Middle elevations include areas above the desert scrub to approximately 7000' and roughly delimited by the Pinon-Juniper woodland. Montane habitat is all areas above 7000'. For the present section, all species which commonly occur in the particular habitat are included. In subsequent sections, only those species which have their distributional center of abundance in a particular habitat will be considered. Species which commonly range over more than one habitat are termed widespread.

Family composition in the different habitats shows a varied pattern (Table 1). The desert scrub habitat is dominated by Pierids and Lycaenids, riparian/agricultural by Hesperiids and Nymphalids, middle elevations (which contains the most total species) by Hesperiids and Lycaenids and montane habitat by Hesperiids, Lycaenids and Nymphalids. Of the minor families, Papilionids and Satyrids are most important at the higher elevations and Riodinids at lower elevations. Similar habitat differences were noted by Emmel and Emmel (1963).

### Biogeographical Analysis

The location of Clark County in the northern Mojave Desert and in close proximity to the Great Basin and Sonoran deserts make a biogeographical analysis of the biota of interest. Each species was assigned to an element based on the geographical range of the taxon (Table 2). The butterfly fauna of Clark County exhibits complex biogeographical relationships (Table 3). Forty-four percent of the species have distributions mainly in the North American deserts. About one-half are largely restricted to the Mojave Desert and one-quarter of the others are widespread desert region species. The remaining species of these have distributions in either the Great Basin or Sonoran deserts. Almost 41% of the county's species are widespread in distribution throughout North America, in western United States or in tropical regions.

Species with a widespread ecological distribution in the county are mostly of relatively wide distribution in the west as a whole or in desert regions. Desert scrub species are largely of Mojave Desert distribution. Mojave Desert and Rocky Mountain elements dominate at middle elevations. Principally montane species belong to the western North America and endemic elements.

# Phenology and Voltinism

Seasonality and voltinism of the Clark County butterfly fauna were examined on the basis of number of locality-date records for each 10 day period of each month (Table 4) and by evaluating wear of specimens. It must be recognized throughout that annual climatic differences tend to lengthen the apparent flight season and to smooth out peaks and valleys of abundance.

For the county as a whole, butterflies have been recorded in every month of the year. Species number and abundance are greatest from May through July although considerable numbers of species are present in all months from April to October (Table 4). Approximately equal numbers of species are present in each month from March to October at low elevations. The number of records, however, is greatest in April and September-October indicating the peak flight period. The spring peak is mainly in desert scrub habitats; the peak in fall is of species associated with desert scrub and cultivated habitats. The flight season at high elevations extends from late April to October with a peak in June and July.

The Mojave Desert biogeographic element has a strong peak in April and a minor peak in September. The fall peak may be controlled largely by the occurrence of summer rainfall. Undoubtedly, the availability of adult and larval food resources restricts the flight season and number of broods of these, mostly desert scrub inhabiting, species. Certain species of this group occur in more riparian habitats and fly throughout the summer or occur at higher elevations and are summer univoltines.

The southwest desert element shows peaks in summer and fall. This group contains species which are widespread in the county or occur largely in riparian and

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agricultural habitats and have long flight seasons. The phenology of the widespread element is similar to that of the southwest desert element but becomes common somewhat earlier in the year. This group contains species found in desert scrub in spring and in cultivated areas in summer and fall. The western North America and tropical elements also show a similar seasonal pattern. They are both composed of a number of common, widespread species in the county.

The endemic element has a single peak in summer as expected of species inhabiting montane habitat.

The Great Basin element is most common in spring reflective of its composition of several spring, univoltines The Rocky Mountain element has a spring and summer peak. Too few records are available for the other elements to draw conclusions on them.

Sufficient records exist for 99 species to reach some conclusons on their voltinism (Table 2). Thirty-nine species appear to be univoltine within the county (Table 5). Twenty-eight of these occur at middle to high elevations. At middle elevations most univoltines are vernal with S. behrii, L. weidemeyerii and C. sthenele as summer univoltines and A. alliae and E. b. ellisi as fall univoltines. Montane univoltines fly in summer except for the spring flying E. brizo. Eight additional univoltines occur largely in desert scrub. Seven of these are vernal and only E. e. dammersi is autumnal. There are only two (both autumnal) univoltines in riparian and agricultural habitats. The only widespread univoltine is N. antiopa.

Twenty species appear as bivoltines (Table 5). These include four montane species (H. comma, H. juba, P. satyrus, P. zephyrus) with summer and fall broods. At middle elevations, there are six bivoltines. Four (P. indra, C. spinetorum, C. siva, P. minuta) have spring and summer broods, one (C. sheridanii) has spring and fall broods and one (C. pertepida) has summer and fall broods. Five desert scrub species are bivoltine. One (M. leda) occurs in mesquite stands and has summer and fall broods. The remaining four (P. rudkini, C. neumoegeni, C. california, E. chalcedona) have regular spring broods and irregular fall broods, apparently dependent upon summer rains. These species may be univoltine in some years. Papilio rudkini has occasional emergences during mid summer in some years and C. neumoegeni is known to have had two successive spring broods. The four bivoltines (O. yuma, A. campestris, C. nemesis, L. archippus) of riparian and agricultural habitats and the one widespread bivoltine (V. virginiensis) have summer and fall broods.

Forty Clark County species are considered multivoltine or have continuous emergences throughout their flight season (Table 5). The number and timing of broods of some may vary from year to year and with elevation. Certain species included here such as A. mormo may be single brooded in some colonies but have an overall pattern which indicates several broods. Such patterns need further study and may be related to the seasonal availability of suitable foodplants.

Nearly 40% of the Clark County butterfly fauna is univoltine. This frequency of univoltines is intermediate to that reported for several California butterfly faunas (Shapiro 1975). Analysis of voltinism by habitat (Table 5) presents difficulties due to the presence of widespread species which either stray to high elevations or have different breeding strategies under different ecological conditions. For these reasons, species were separated by principal habitat preference. The overall pattern is an increase in univoltinism with increasing elevation (Table 5) as noted in other studies (Shapiro 1974, 1975). Univoltinism is primarily vernal at low (70%)

and middle (62%) elevations and a summer phenomenon (93%) at high elevations. Vernal univoltinism is the usual situation in long summer faunas (Shapiro 1975) and the northern Mojave Desert pattern contrasts sharply with the exception found for a Sonoran Desert butterfly fauna (Austin 1978). The difference between the two desert faunas can be accounted for by the lack of a regular summer rainy season in the Mojave Desert. Multivoltinism in low desert butterflies is largely limited to species with desert riparian affinities where foodplants remain green through the summer.

Of the important biogeographical entities in Clark County, the Mojave Desert element has the greatest number of univoltines (Table 6). Species which fly in spring and/or fall (spring and fall univoltines, spring-fall bivoltines) comprise 68% of the species in this element. Thus the group as a whole exhibits adaptation to the generally favorable springs, often favorable falls and usually unfavorable remainder of the year that is typical of the Mojave Desert. The Great Basin and Rocky Mountain elements are also represented by a large proportion of (mainly spring) univoltines (Table 6).

The southwest desert and widespread elements are largely multivoltine (Table 6). Most of these species are either widespread in the county or occur in riparian and Phenology, voltinism and abundance are highly variable especially in the lower desert. These variations, as mentioned above, are ultimately due to various climatic factors, particularly rainfall and proximately to the resultant condition of the vegetation. Warm temperatures in late winter promote early emergence of a number of species. Later in spring, this early flight may be interrupted or terminated

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TABLE 1. Composition of the Clark County, Nevada, butterfly fauna by families.

	County (%)	Desert Scrub (%)	Riparian/ Agriculture (%)	Middle Elevations (%)	Montane (%)
Megathymidae	1.6	2.4	0.0	3.1	0.0
Hesperiidae	22.2	11.9	26.8	21.9	22.7
Papilionidae	4.8	2.4	2.4	4.7	4.5
Pieridae	12.7	26.2	17.1	15.6	13.6
Riodinidae	3.2	4.8	4.9	1.6	0.0
Lycaenidae	24.6	31.0	17.1	26.6	22.7
Libytheidae	0.8	2.4	2.4	1.6	0.0
Nymphalidae	2.4.6	16.7	22.0	18.8	31.8
Heliconiidae	0.8	0.0	2.4	0.0	0.0
Danaidae	1.6	2.4	4.9	3.1	2.3
Satyridae	3.2	0.0	0.0	3.1	2.3
Total Species	126	42	41	64	44

TABLE 2. Biogeographic affinities, voltinism and habitat data for Clark County, Nevada, butterflies.

Taxon	Biogeographical Affinity <sup>1</sup>	Volti	inism <sup>2</sup>	Primary <sub>3</sub> Habitat
Agathymus alliae ssp.	MD	U	(F)	ME
Megathymus yuccae navajo	MD	U	(S)	DS
Lerodea eufala	WS	М		RA
Atrytonopsis python	SWD	-		-
Ochlodes yuma	MD	В	(SU,F)	RA
Atalopedes campestris	WS	В	(SU,F)	RA
Polites sabuleti ssp.	WNA	М		RA
Polites draco	RM	_		-
Hesperia comma harpalus	GB	В	(SU,F)	М
Hesperia nevada	SN			М
Hesperia pahaska martini	MD			-
Hesperia juba	WNA	В	(SU,F)	M
Hylephila phyleus	WS	М		RA
Copaeodes aurantiaca	WNA	М		RA
Pholisora libya libya	MD	М		RA
Pholisora gracielae	MD	М		RA
Pholisora alpheus oricus	GB	U	(S)	ME

Taxon	Biogeographical Affinity <sup>l</sup>	Voltinism <sup>2</sup>	Primary <sub>3</sub> Habitat
Heliopetes domicella domicella	т	-	-
Heliopetes ericetorum	WNA	M	WS
Pyrgus scriptura	WNA	M	WS
Pyrgus communis	WS	M	WS
Erynnis brizo burgessi	RM	U (S)	M
Erynnis funeralis	T	М	RA
Erynnis meridianus meridianus	SWD	М	М
Erynnis telemachus	RM	U (S)	ME
Chiomara asychis georgina	T	-	-
Systasea zampa	SWD	M	RA
Thorybes pylades	WS	-	_
Polygonus leo arizonensis	SWD	-	-
Epargyreus clarus huachuca	SD	-	ME
Battus philenor philenor	WS	-	-
Papillio bairdii bairdii	WNA	_	М
Papilio rudkini	MD	B (S,F)	DS
Papilio indra martini	MD	B (S,SU)	ME
Papilio rutulus rutulus	WNA	U (SU)	М
Papilio multicaudatus	WNA	_	ME
Neophasia menapia	WNA	U (SU)	М
Pieris beckerii beckerii	WNA	м	ME
Pieris sisymbrii elivata	RM	U (S)	ME
Pieris protodice protodice	WS	м	WS
Pieris rapae	WS	М	WS
Colias eurytheme	WS	M	WS
Colias philodice philodice	WS	_	_
Colias alexandra edwardsii	GB	U (S)	DS
Colias cesonia	WS	м	WS
Phoebis sennae marcellina	T	-	_
Eurema mexicana	т Т	_	_
Eurema nicippe	WS	М	WS
Nathalis iole	т	M	WS
Anthocaris pima	SD	U (S)	DS
Anthocaris sara thoosa	MD	U (S)	ME
Euchloe hyantis lotta	MD	U (S)	ME
Apodemia mormo mormo	GB	м	WS
Apodemia palmeri marginalis	MD	м	DS
Calephelis nemesis californica	SCM	B (SU,F)	
Calephelis wrightii	SCM	м	RA
Satyrium behrii behrii	SN	U (SU)	ME
Ministrymon leda	SD	B (SU,F)	
Callophrys fotis fotis	GB	U (S)	ME
Callophrys eryphon eryphon	WNA	- (3)	-
Callophrys spinetorum	WNA	B (S,SU)	
	RM	- (-,,	
<u>Callophrys siva siva</u> <u>Callophrys sheridanii comstocki</u>	MD	B (S,SU) B (S,F)	ME ME
Atlides halesus corcorani	ANW		
Strymon melinus pudica		М	DS
Lycaena helloides	SWD	М	WS
	WS	М	RA
Lycaena dorcas castro	RM Th	-	-
Brephidium exilis	T	M	WS

Taxon	Biogeographical Affinity <sup>1</sup>	Voltinism <sup>2</sup>	Primary3 Habitat
Leptotes marina	Т	М	WS
Hemiargus ceraunus gyas	SWD	М	ws
Hemiargus isola alce	WS	M	WS
Plebejus melissa melissa	WNA	U (F)	RA
Plebejus icarioides evius	SCM	U (SU)	М
Plebejus shasta charlestonensis	E	U (SU)	М
Plebejus acmon acmon	SN	М	WS
Plebejus acmon texanus	SWD	M	WS
Everes amyntula	WNA	U (SU)	М
Euphilotes battoides nr. ellisii	MD	U (F)	ME
Euphilotes battoides martini	MD	U (S)	DS
Euphilotes battoides baueri	GB	-	-
Euphilotes enoptes ssp.	E	U (SU)	M
Euphilotes enoptes dammersi	MD	U (F)	DS
Euphilotes mojave ssp.	MD	U (S)	ME
Philotiella speciosa speciosa	MD	U (S)	DS
Glaucopsyche lygdamus ssp.	MD	U (S)	DS
Glaucopsyche lygdamus oro	RM	U (SU)	М
Celastrina argiolus cinerea	RM	M	WS
<u>Libytheana</u> <u>bachmanii</u> <u>larvata</u>	SWD	-	WS
Asterocampa celtis montis	SD	-	ME
Limenitis archippus absoleta	SWD	B (SU,F	
<u>Limenitis</u> <u>weidemeyerii</u> <u>angustifasc</u>		U (SU)	ME
<u>Limenițis</u> <u>weidemeyerii</u> <u>nevadae</u>	Е	U (SU)	М
Adelpha bredowii eulalia	SWD	М	WS
Vanessa atalanta rubria	WS	М	WS
Vanessa virginiensis	WS	B (SU,F	
Vanessa cardui	WS	М	WS
<u>Vanessa</u> <u>annabella</u>	WNA	М	WS
Precis coenia	WS	М	WS
Nymphalis californica	WNA	U (SU)	М
Nymphalis milberti furcillata	WNA	U (SU)	М
Nymphalis antiopa antiopa	WS	ບ (ຣບ)	WS
Polygonia satyrus satyrus	WS	B (SU, E	
Polygonia zephyrus	WNA	B (SU,F	
Chlosyne palla vallismortis	MD	U (SU)	М
Chlosyne neumoegeni neumoegeni	MD	B (S,F)	
Chlosyne lacinia crocale	SWD	М	RA
Chlosyne californica	MD	B (S,F)	DS
Anthanassa texana texana	T	-	==
Phyciodes tharos distincta	SWD	-	-
Phyciodes phaon	WS	U (F)	RA
Phyciodes pallida barnesi	RM	-	-
Phyciodes mylitta mylitta	SN	-	M
Thessalia leanira alma	GB	U (S)	DS
Poladryas minuta arachne	RM.	B (S,F)	
Euphydryas chalcedona kingstonensi		B (S,F)	
Euphydryas anicia morandi	E	U (SU)	М
Euphydryas anicia ssp.	RM	U (S)	ME
Speyeria zerene carolae	E	ບ (ຣບ)	M

Taxon	Biogeographical Affinity <sup>1</sup>	Volt	inism <sup>2</sup>	Primary <sub>3</sub> Habitat
Euptoieta claudia	WS	_		
Agraulis vanillae incarnata	SWD	M		WS
Danaus plexippus plexippus	WS	M		WS
Danaus gilippus strigosus	SWD	M		WS
Cyllopsis pertepida dorothea	RM	В	(SU,F)	ME
Coenonympha california california	SCM	***		
Coenonympha ochracea brenda	GB	U	(SU)	M
Cercyonis sthenele ssp.	E	U	(SU)	ME

E = Endemic, MD = Mojave Desert, GB = Great Basin, SD = Sonoran Desert, SWD = Southwest Desert, SN = Sierra Nevada, RM = Rocky Mountain, SCM = Southern California Mediterranean, T = Tropical, WNA = Western North America, WS = Widespread.

TABLE 3: Biogeographic affinities of the Clark County, Nevada butterfly fauna.

			Primar	/ Habitat		
Element	Entire County	Widespread	Agriculture/ Riparian	Desert Scrub	Middle Elevations	Montane
	(%)	(%)	(%)	(%)	(%)	(%)
Endemic	4.0	0.0	0.0	0.0	0.0	25.0
Mojave Desert	18.3	0.0	17.6	66.7	40.0	5.0
Great Basin	6.3	3.7	0.0	13.3	10.0	10.0
Sonoran Desert	4.0	0.0	0.0	13.3	5.0	0.0
Southwest Desert	11.1	18.5	17.6	0.0	0.0	5.0
Sierra Nevada	3.2	3.7	0.0	0.0	5.0	0.0
Rocky Mountain	9.5	3.7	0.0	0.0	30.0	10.0
So. California Mediterranean	3.2	0.0	11.8	0.0	0.0	5.0
Tropical	7.1	11.1	5.9	0.0	0.0	0.0
Western North America	15.1	11.1	17.6	6.7	10.0	35.0
Widespread	18.3	48.1	29.4	0.0	0.0	5.0
Number of species	126	27	17	15	20	20

 $<sup>^2</sup>$  U = univoltine, B = bivoltine, M = multivoltine, S = spring, SU = summer, F = fall, dash indicates insufficient data.

 $<sup>^3\</sup>mathrm{DS}$  = Desert Scrub, RA = Riparian/Agriculture, ME = Middle Elevations, M = Montane, WS = Widespread, dash indicates insufficient data.

TREE 4. Seasonal distribution of the Clark County, Nevada, butterfly fauma by 10 day periods (each date-locality record counts as one) .

MEGANITYOUTURE   N	Taxon					Mo	Month						
		5	Cr4	M	A			ņ	A	w	0	z	Ω
	MEGATHYMIDAE												
12   10   10   10   10   10   10   10	A. alliae	1			1	i		1	- 1	1	'n		5 6
is   1   221   2-2   212   5710   665   32-      1   1   1   1   4310   432   2-1   7511   432   11-     1   1   1   1   1   4310   432   2-1   7511   432   11-     1   1   1   1   1   1   1   1   1   1     1   1   1   1   1   1   1   1   1     1   1   1   1   1   1   1   1     1   1   1   1   1   1   1   1     1   1   1   1   1   1   1     1   1   1   1   1   1     1   1   1   1   1   1     1   1   1   1   1   1     1   1   1   1   1   1     1   1   1   1   1   1   1     1   1   1   1   1   1     1   1   1   1   1   1     1	M. yuccae	i	!	2	01019	S		i	i	1	!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	i	1
Table 1	HESPERIIDAE												
vorticol.           4 310         4 32         2             vorticol.           4 310         4 32         2          2           compositification           4 310         4 32         3         3 <td>L. eufala</td> <td>1</td> <td>1 1</td> <td>1</td> <td>1</td> <td>-</td> <td></td> <td>8</td> <td>Н</td> <td></td> <td>9</td> <td>2</td> <td></td>	L. eufala	1	1 1	1	1	-		8	Н		9	2	
National	A. gython	1	!	!	1	1	1	!!!!	1	1	1	1	1
Compositified  <	O. yuma	1	!	1	1 1	1				7 5 11	432	11-	1
and pulletic <t< td=""><td>A. campestris</td><td>1</td><td></td><td>!</td><td></td><td>!</td><td>1</td><td>2</td><td>1</td><td>1</td><td>2 1 2</td><td>1</td><td>!</td></t<>	A. campestris	1		!		!	1	2	1	1	2 1 2	1	!
Occome		1	1	1	-21	11-	3	1	112		2	1 - 1	1 1
Decirio	P. draco	1	.!	1	1 1	1	- 1 -	!	1	!	1	1	
Debte-side		!!!!	1 1	1		- 1 1		00	4 1 3	1.18	2 4 1	1	! ! !
pathonisis	H. nevada		!!!			- 1 -			1			1	1
jube             12- <td>H. pahaska</td> <td>1</td> <td>!!!</td> <td>1</td> <td>1</td> <td>1</td> <td>1 1 1</td> <td></td> <td>   </td> <td>1</td> <td>1</td> <td>1</td> <td>1</td>	H. pahaska	1	!!!	1	1	1	1 1 1			1	1	1	1
phyleus           1 1 6 1 4 1 -         5 616 7910 1079 91221         151412 832           aurantiaca           111 152 654 6710 9128 727 948 1163 512           Libya           -11 531 331 3351          35 5 21            dandbaus           -12 2813 551                 dantbaus           -12 2813 551                 dantbaus           -12 2813 551                 dantbaus                    dantbaus                     dantbaus           147 152023 161431 1688 224 5132 11644                corrupture <t< td=""><td>H. juba</td><td>1</td><td>1</td><td>1 1</td><td></td><td> 2</td><td></td><td></td><td>1 1</td><td>1 - 1</td><td>1</td><td>1</td><td>1</td></t<>	H. juba	1	1	1 1		2			1 1	1 - 1	1	1	1
Secretariacea		1			191	4 1 -		7 9 10	7	9 12 21	15 14 12	8 3 2	1 1 -
115pa       -11   531   335  1     355   21-     355   21-     355   315       355   315       355   315       355   315       355   315       355   315       355   315       355   31		1	1	111	152	654	7	9 12 8	2	9 14 8	S	512	
gracielae          -2-         31-         143         431         1-3         311         -i-            alpheus          -12         2813         551                demicella                    actiotum           1         1         7         152023         161431         1688         224         51321         16149         4           scriptuma            4         3         2         1          1             communic            4         3         2         1          1          1           prize             4         3         2         1          1           prize	P. libya	1 1	1	1	- 1 1	531	33,	1	1 1 1		-	1	1
dippeus          -12         2 813         5 51		1	1	1		3 1 -	143	431			1 1	1	:
demicella  -		1	1	- 12	œ			1	ř ř			1	
extroctorum            147         152023         161431         1688         2 2 4         513 21         16149         4           scriptura           2 3 8         6 3 2         4 3 9         2 11          11 2        2         -1-           communis          11 -         -2 9         10 2733         3122 15         16 1743         332315         14 3 5         7 816         2126 24         15131           brizo           -4         2 310         6 8 5         3 3   <						! ! !		-	1 1		H	1	!
scriptura            2 3 8         6 3 2         4 3 9         2 1 1          1 1 2        2         - 1 1           commanis          1 1 -         - 2 9         10 27 33         3122 15         16 17 43         332 315         14 3 5         7 8 16         21 26 24         15 13 1           brizo                   tenzalis                  funcacalis           2 3 10         6 8 5         3 3 -		1	!	1		20	16 14 31	00	-		16 14 9		!
communic          11-         -29         10 27 33         3122 15         16 17 43         33 23 15         14 3 5         7 8 16         21 26 24         15 13 1           brizo		1		2	ന	m	ന	Н	!!!		1		!
barizo4 2 310 6 8 5 3 3			11-		10 27 33	31 22	16 17	33 23 15	ന	00	21 26 24	15 13 1	131
funezalis23 391 372 2-2 1121 -54 .111		1	1	4		00	ന	1			8		1
	E. funeralis	1	-	N	σ'n.	7	- 1	-	- 1	S	r=l	1	1

	ר	G,	Σ	A	Σ	ט	ט	A	S	0	z	۵
E. meridianus	1 1	1	- 1 2	227	757	10 16 14	621	1	12-			1
. telemachus	1	1	1 1	1 1	1 2 2	1	1	1	1	1 1	1	1
. asychis	1	1	1	1 1	1	1 1	1	1 1	1	1	1	1
sampa	1 1	1	1	- 3 -	1 - 1	1 1	2	1 1	- 2 1	1	1	1
. pylades	1	1	1			2	1 1	1	1 1		1 1	1
P. leo	1 1	1	1	1	!	1 5 1	1	1	- 1 1		!	1
g. clarus	1 1	1	1	1	- 12	1-1	1 1	!	1	1	1	i
PAPILIONIDAE												
3. philenor	1 1	1 1 1	1	1	1	- 1 1	- 12	1 - 2	1 - 1	1	1	1
. bairdii	1	1	1	1	1	- 2 1	1 1	1	1		1	1
P. rudkini	1 1	- 2 -	- 410	10 25 22	20 26 15	5 2 5	3 1 2	- 2 3	4 3 22	145 -	1 - 1	1
indra	1 1	1	- 1 -	- 2 2		- 1 3	2	1 1	1		1	i
. rutulus	1	1	1	1 1	3	1 7 16	1796	1	1 1	1	1 1	1
P. multicaudatus	1 1	i i	1 1	1	141	1 - 1	1 1	1	1 1	1	1 1	i
PIERIDAE												
W. menapia	1	1	!	1	1	1 1	1	4 2 1	1 1	1		i
P. beckerii	1	1	1 1 6	7 5 4	977	7 5 10	6 4 2	4	2 - 2	2 2 1	- 1 -	1
sisymbrii	1	1	- 18	5 20 9	63-		1	1	1	1	1	i
. protodice	1 - 1	386	5 6 10	12 32 28	3336 25	24 37 38	29 23 19	11 2 5	7 6 8	10 9 11	15 16 3	4
. rapae	1	133	5 4 6	4 5 11	7 13 8	11 7 11	1087	453	3 4 4	9 13 8	3 2 3	6 1
. eurytheme	1	- 12	5 2 8	61219	15 21 11	13 18 26	26 26 19	16 13 20	24 29 39	36 33 22	14 10 2	11
C. philodice	1	1	1	1	1	1 1	1	1 1	1	- 1 -	1	i
. alexandra	1	1	1	- 25	12-	1	1	1 1		- 1 -	1	i
. cesonia	1	- 1 -	1	- 64	5 7 5	3 2 2	616	1 - 1	1	1	- 1 -	i
sennae	1 1	1	1	141	1 1 -	1 - 1	2	- 1 -		1	1	1
. mexicana	1	1	1	- 2 -	1 - 1	1	!	1	1	1	1	i
3. nicippe	1	14-	1 2 2	487	12 13 5	2 - 5	8 6 4	5 1 2	- 4 3	81310	8 5 -	-
N. iole	1	3 1 1	1	1 10 3	8 20 11	11 8 18	15 3 7				,	•

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Tawoii	5	ы	W	A	M	D	D	A	S	0	z	Ω
A. pima	1 1	- 2 4	7 5 13	497	2 5				1	:		
	1	- 1 -	- 112	5 14 11	5 2 1	1 1 1	1	1	1	1	1 1	i
E. hyantis	1	1	2 4 10	9 14 14	- 5 6	1 1	1	1	1	1	1	
RIODINIDAE												
mormo	1	2 1 1	4 3 5	8 22 11	8 8 1	1 1 4	144	- 1 4	9 11 17	14 13 11	61-	1
A. palmerii	1	1	1		2 5 6	9 4 4	5 1 5	133	8 6 6	2 2 -	1	
C. nemesis	1	1	1	1		1		1	111	- 1 1	1 1	i
C. wrighti	1	1	1	1	1	1	1		- 3 1	1	1	i
LYCAENIDAE												
S. behrii	1	1	1	1	1	1 1 4	- 1 -	1	1	1	1	
M. leda	1	1	1 1	- 1 -	1 - 1	1 - 3	2 2 2	11-	1	- 1 -	1	1
C. fotis	1	1	7	6 10 15	8 2 -	- 1 -	1	1		1	1	i
C. eryphon	1	1		1 1	- 1 -	1	1	1	1	1	1	
C. spinetorum	1		- I - I	2 - 5	1 1 2	1 2 4	161	1		1	1 1	į
C. siva	1	1 1	3	269	6 5 3	7 9 15	9 6 3	1 1	1	1	1	1
C. sheridanii	1 1	1	7	5 4 -	1	1	1	2	3 1 -	1	1 1	i
A. halesus	1	2	3 6 8	8 10 4	2 7 6	8 1 6	6 3 5	3 1 -	3 10 6	7 5 6	62-	2 1 -
S. melinus	1	1	1	246	15 15 11	11 4 19	12 22 13	723	557	7 3 8	4 1 -	į
L. helloides	1	1		1 1	- 1 -	2 1 1	1 - 1	1 - 1	1 1 4	2 1 3	1	1
L. dorcas	1 1 1	1		1	1 1	1 1		1 1 1	1	1	1 1	i
B. exilis	1		5 3 9	8 13 6	12 17 18	12 12 26	18 15 9	7 2 14	17 13 20	26 31 23	25 17 4	7 1 -
L. marina	1	1 1	2	9 6 5	14 21 18	24 25 44	37 21 17	10 4 8	4 5 8	3 5 6	4 1 -	į
H. ceraunus	1	1 1		151	5 4 5	2 3 5	13814	6 3 5	2 10 8	12 11 5	8 2 -	- 2 -
H. isola	1	1 1		3 8 6	9 14 9	10 7 24	20 15 17	3	1 1	1	1 1	į
P. melissa	1	1	-	1	1	1	1		2 - 1	1 1 1	1 1	1
P. icarioides	1 1	1			- 3 1	2 8 16	23 18 12	2 2 4	1	1	1 1	i
P. shasta	1		-	-	1	1	3 1 6	- 2 -	1	1	1	į
D a acmon												

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P. a. texanus	1	1	1	- 5	4 9 4	5 3 11	1996	2 1 2	1 2 1	3 8 2	1	1
amy	1	1	1 1	1 1	- 12	3 3 3	123	1 - 1	1	1	1 1	1
E. b. martini	1	1	- 2 2	3 5 2	9 10 4	1	1	1	1	1	1	1
E. b. baueri	1	1	1 1	- 1 -	1	1	1 1	1	I I I	1 1	1 1	1
b. ellisii	1	1	1	1	1	1	:	- 12	3 1 -	1	1 1	1
enoptes ssp.	1	1	1	1	1 1	2 3 1	2 5 3	- 1 -	1	1	1	1
E. e. damersi	1	1	1 1	1	1	1	1	1	- 5 4	1	1	1 1
E. mojave	1	1	1 1	1	131	1	1	1 1	1 1	1	1 1	:
speciosa	!!!	1	1	- 1 -	1	- 1 -	1	1 1	1	1	1	
G. lygdamus ssp.	1 1	1	1	267	11-	1	1	1	!	1	1	1
G. 1. oro	1	1	1 1	1	1	- 1 -	1 - 1	1	1	1	1	1
C. argiolus	1	1	- 17	3 5 11	6 8 14	9 16 21	18 18 17	7 4 4	5 9 5	121	1	1
LIBYTHEIDAE					-							
L. bachmanii	 	1	1	1	1	1	1	- - -	122	6 7 15	1152	- 2 -
NYMPHALIDAE												
L. archippus	1	1	i i i	1	1 -1	2 4 3	3 1 2	3 - 2	2 - 3	4 1 1	1	1
L. w. anqustifascia	1 1	1	1	1	- 11	1 - 2	1		1 1	1 1	1	1
L. w. nevadae	1	1	1	1	1	4 11 29	39 13 14	111	1 1	1	1 1	1
A. bredowii	1	1	1 1	- 2 1	264	5 9 24	1152	111	4 8 12	493	1	1
V. atalanta	1	1	1	- 2 2	1 - 1	143	2 2 1	1	4	3 11 5	3 - 1	1
V. virginiensis	1	1	1	1		- 4 4	3 4 2	1 1	- 12	123	1	1
V. cardui	1 1 2	4 4 3	4 4 20	18 26 24	20 24 13	9 9 14	8 12 12	8 7 11	12 20 27	28 22 21	14 14 3	5 2 1
V. annabella	1 1	3 7 3	355	7 6 18	14 14 7	71 11 01	7 14 8	2 3 5	5 11 15	15 18 21	9 11 2	1 2 1
P. coenia	1	1	1 1	- 11	133	327	3 2 5	1 - 3	3 6 9	265	3 1 -	1
N. californica	1	1 1	1	1	1 1	115	2 - 1	1 1 -	1	- 1 -	1 1	1
N. milberti	1	1 1	1	1	- 1 -	E - 3		1 1	1	1	1	1
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TABLE 5. Voltinism of the Clark County, Nevada, butterfly fauna.

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Primary	No. of	Univoltines	Bivoltines	Multivoltines
Habitat	Species	(%)	(%)	(%)
Widespread	27	3.7	3.7	92.6
Agriculture—Riparian	17	11.8	23.5	64.7
Desert Scrub	15	53.3	33.3	13.3
Middle Elevations	20	65.0	30.0	5.0
Montane	20	75.0	20.0	5.0
County	99	39.4	20.2	40.4

TABLE 6. Voltinism of the Clark County, Nevada, butterfly fauna to biogeographic affinities.

Biogeographical			
Element		Percent	
	Univoltine	Bivoltine	Multivoltine
Endemic	100.0	0.0	0.0
Mojave Desert	54.5	31.8	13.6
Great Basin	71.4	14.3	14.3
Sonoran Desert	66.7	33.3	0.0
Southwest Desert	0.0	11.1	88.0
Sierra Nevada	50.0	0.0	50.0
Rocky Mountain	55.6	33.3	11.1
So. California Mediterranean	33.3	33.3	33.3
Tropical	0.0	0.0	100.0
Western North America	37.5	18.8	43.6
Widespread	10.5	15.8	73.8



TABLE 5. Voltinism of the Clark County, Nevada, butterfly fauna.

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Montane	20	75.0	20.0	5.0
County	99	39.4	20.2	40.4

#### **Book Review**

Herbivores: Their interaction with secondary plant metabolites. Edited by Gerald A. Rosenthal and Daniel H. Janzen. Academic Press, New York, 1979. 718 pp. \$59.50.

The title of this book is misleading. It's really an updating and attempted resynthesis of that part of chemical ecology dealing with chemical mediation of herbivore-plant interaction. The emphasis is on insect herbivores and secondary plant compounds. The 20 chapters are divided into eco-evolutionary and primarily chemical. The latter are very competent reviews of what ecologists may derisively call "chicken-wire chemistry" and their bibliographies are absolutely indispensible for anyone working in this field. The former, where the fun is, display once again that chemical ecology reduces intellectually to the ploy-counterploy model published by Fraenkel in 1959, and that its practitioners must constantly do battle against unjustified assumptions of adaptivity, "function," and evolutionary history. The most interesting chapter in the book is by Janzen, who cautions his colleagues against all these deadly sins and in the process spins a tall tale about phylogenetic inertia (which might even be true). His caution that "herbivores do not eat Latin binomials" should apply especially to Lepidopterists, long plagued by questionable host records and the assumption that "a rose is a rose is a rose." Gertrude Stein was not a biologist. Hard-headed hypothesis testers may well feel that many chemical ecologists aren't either. Whether or not one is happy about chemical ecology as an explanatory or a predictive science, this is an important book.

Arthur M. Shapiro, Department of Zoology, University of California, Davis, CA 95616.

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Manuscript Format: Two copies must be submitted (xeroxed or carbon papered), double-spaced, typed, on 8½ x 11 inch paper with wide margins. Number all pages consecutively and put author's name at top right corner of each page. If your typewriter does not have italic type, underline all words where italics are intended. Footnotes, although discouraged, must be typed on a separate sheet. Do not hyphenate words at the right margin. All measurements must be metric, with the exception of altitudes and distances which should include metric equivalents in parenthesis. Time must be cited on a 24-hour basis, standard time. Abbreviations must follow common usage. Dates should be cited as example: 4. IV. 1979 (day-arabic numberal; month-Roman numeral; year-arabic numeral). Numerals must be used before measurements (5mm) or otherwise up to number ten e.g. (nine butterflies, 12 moths).

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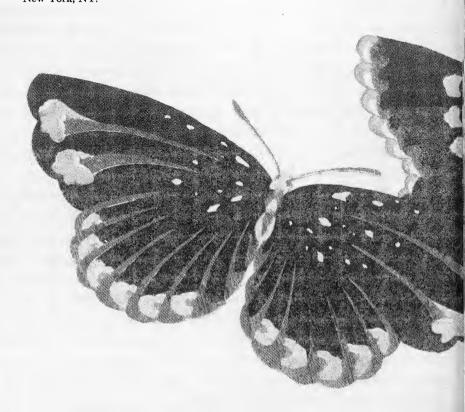
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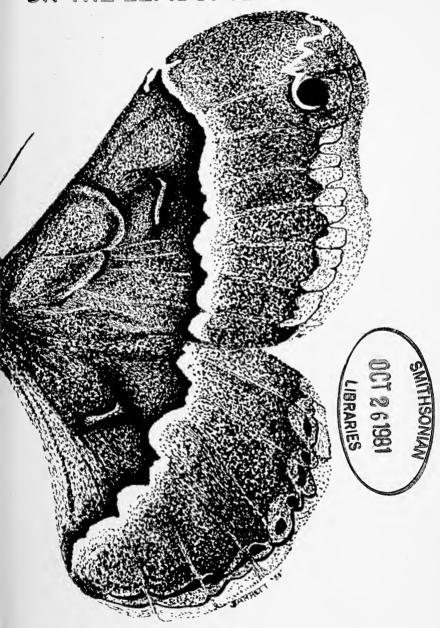
Butterflies of Clark County, Nevada George T. & Anna T. Austin

Book Review

COVER ILLUSTRATION: Black and white adaptation of a color illustration from *A Flight of Butterflies*. Reprint permission given by The Metropolitan Museum of Art, New York, NY.



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## Nantucket Pine Tip Moth, Rhyacionia frustrana, in Kern County, California: Integrated Control and Biological Notes (Lepidoptera: Tortricidae, Olethreutinae)

Dennis M. Poore

Kern County Department of Agriculture, Bakersfield, California 93302

Abstract. Rhyacionia frustrana had four generations on Monterey pine (Pinus radiata) in the San Joaquin Valley of California during 1974 with summer generations of approximately six weeks. In California, the moth prefers P. radiata, but has been found in association with eight other pine species. The use of chemical, biological and cultural control practices has evidently lead to its eradication in a Kern County pine plantation.

The Nantucket pine tip moth, Rhyacionia frustrana (Comstock), is known to have a wide geographical distribution. Powell and Miller (1978) show the following range: Central America (Guatemala, Honduras and Nicaragua), southern Mexico (Oaxaca State), West Indies (Cuba, Jamaica and Dominican Republic), eastern United States (eastern Texas and Florida, north to Missouri and Massachusetts). This pine tip moth was probably introduced into California on infested nursery stock from the eastern United States sometime in the late 1960's, according to information assimilated by a task force of various State and Federal agencies. In California five counties (San Bernardino, San Diego, Riverside, Orange and Kern) have been known to have infestations. The hosts1 recorded for R. frustrana in California are Pinus attenuata Lemmon (Knobcone pine); P. canariensis Sweet ex K. Spreng. (Canary Island pine); P. halepensis Mill. (Aleppo pine); P. jeffreyi Grev. and Balf. (Jeffrey pine); P. nigra Arnold (Austrian Black pine); P. radiata D. Don. (Monterey pine); P. roxburghii Sarg. (Chir pine); P. sylvestris L. (Scotch pine); P. thunbergiana Franco (Japanese Black pine) (personal communication - T. D. Eichlin, Insect Taxonomy Laboratory, California Department of Food and Agriculture). Nine species of pines (excluding exotics and ornamentals) in the eastern United States have been recorded as hosts (Powell and Miller, 1978).

Rhyacionia was first detected in Kern County on November 10, 1971. The specimens were collected from Monterey pines (which is the preferred host in California) at a Christmas tree farm, Kern County, Wasco, California, Section 36, Township 26s. Range 24e. M.D. The damage by burrowing larvae caused severe dieback to the terminals. The dieback

<sup>&</sup>lt;sup>1</sup>Not all hosts have been confirmed from rearing records

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caused secondary and lateral shoots to form, which resulted in reduced growth, misshappen and compacted trees.

During 1974, the life history of R. frustrana on Monterey pines at the infested Christmas tree farm was determined. Peak flight was determined by extrapolation from numerical counts of larvae, pupae, pupal cases and adults. The major flight of adults from overwintering pupae occurred April 15; first generation peak flight was May 30 ( $\mp$  3 days); second generation peak flight was July 10 ( $\mp$  4 days); third generation peak flight was August 28 ( $\mp$  4 days). The summer generations took approximately six weeks to complete development. A total of four generations occurred. Brown and Eads (1975) postulated that in San Diego County R. frustrana has two to possibly five generations annually in the southeastern United States, depending on latitude.

A chemical and a biological control agent were applied in 1976 in an attempt at eradication (See Table 1). Surveys were conducted in late summer through fall to determine efficacy of the materials. In the tree farm, only three live pupae from a single Monterey pine were found on October 7, 1976. No insecticides were applied during 1977 and 1978. During 1977 surveys for the pest, only a single larva was found, which was observed in September. No other specimens of the pine tip moth have been collected subsequently.

Table 1
Insecticides Applied During 1976

APPL.			
DATE	MATERIAL*	RATE/ACRE	APPL. METHOD
3/30	carbaryl - D	5 lbs. a.i.	Back pack duster
4/14	B. T.	50 lbs.	Fixed wing aircraft
4/27	carbaryl - D	6 lbs. a.i.	Fixed wing aircraft
5/11	B. T.	60 lbs.	Fixed wing aircraft
5/25	carbaryl - D	6 lbs. a.i.	Fixed wing aircraft
6/8	B. T.	37 lbs.**	Fixed wing aircraft
6/22	carbaryl - D	6 lbs. a.i.	Fixed wing aircraft
7/6	carbaryl - D	6 lbs. a.i.	Fixed wing aircraft

a.i. = active ingredient

B.T. = Bacillus thuringiensis (Berl.)

<sup>\*</sup>Used under S.L.N. registration CA-760011 and CA-760012, Dipel® 1 Dust and Sevin® 10 Dust, respectively.

<sup>\*\*</sup>Expended all available material for the project.

Tree shaping by terminal tipping done at three to four week intervals in 1977 and 1978 was, in fact, a cultural practice aiding in control of the pest. At the same time, any chlorotic tips were also removed and crushed.

R. frustrana had four generations on Monterey pines in the San Joaquin Valley during 1974 with summer generations of approximately six weeks duration. The application of Bacillus thuringiensis (Berl.) and carbaryl at bi-weekly intervals suppressed the tip moth's population to a very low level. Following continuous terminal tipping at three to four week intervals, no specimens have been collected since September 1977.

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# Moths of North America North of Mexico, Supplemental literature: 1

J. C. E. Riotte

Department of Entomology, Bishop Museum, P. O. Box 19000-A, Honolulu, HI 96819

The Journal of Research on the Lepidoptera herein initiates a project to continually update the Moths of North America North of Mexico (MONA) by citing all relevant papers published subsequent to each fascicle produced. We feel the service will maintain the value of MONA and urge all readers to submit citations to Riotte for incorporation into the periodic bibliographies we will publish.

#### Fascicle 6.2, Gelechioidea - Oecophoridae

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#### Fascicle 22.2, Noctuoidea - Lymantriidae

Neil, K. A new subspecies of *Orgyia leucostigma* (Lymantriidae) from Sable Island, Nova Scotia. J. Lep. Soc. 33: 245-247 (1979).

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# Demonstration of Reproductive Isolating Mechanisms in Callosamia (Saturniidae) by Artificial Hybridization

Richard S. Peigler<sup>1</sup>

Department of Entomology, Texas A&M University, College Station, Texas 77843, USA

Abstract. The isolating mechanisms in Callosamia form an elaborate array of complex and numerous ones including premating to postzygotic. The cross C. securifera  $\circ$  X C. promethea  $\circ$  is described for the first time, as well as a complex cross involving C. angulifera and C. securifera, these in addition to ten crosses reported earlier. Some of the results obtained are comparable to those achieved by other workers hybridizing other genera of Lepidoptera. Each isolating mechanism is discussed and interpreted. The relationship between speciation and isolating mechanisms is discussed also, with a review of some recent literature on this topic.

#### Introduction

The genus *Callosamia* Packard is a well-defined North American group of saturniid moths comprised of only three species: *C. angulifera* (Walker), *C. promethea* (Drury), and *C. securifera* (Maassen). Although generally considered to be "well-known", many questions remain unanswered about the phylogeny and ecology of these insects. Moreover, the barriers to hybridization in nature are much more complicated than simple differences in circadian mating behavior. Obtaining and rearing hybrids in the laboratory, and careful studies of natural populations can help elucidate these problems. The purpose of this paper is to figure and describe briefly artificial hybrids obtained since my report on ten earlier crosses (Peigler, 1977), and to discuss some of the evolutionary, ecological, and genetic aspects of the genus, with special reference to isolating mechanisms.

#### **Descriptions of New Crosses**

C. securifera  $\sigma$  X C. promethea  $\circ$ 

Three broods of this cross were reared simultaneously. A brief account of each brood is given followed by a composite description of the stages based on all three broods. Table 1 contains numbers involved in the broods.

Brood 1 was the result of a hand-pairing using a male and female (both from wild-collected cocoons) from Berkeley County, South Carolina.

<sup>&</sup>lt;sup>1</sup>Museum Associate in Entomology, Los Angeles County Museum of Natural History

Some larvae were reared on tuliptree (*Liriodendron tulipifera* L.) and some on sweetbay (*Magnolia virginiana* L.). Those fed on the former grew larger. Many larvae died of disease in the penultimate stadium.

Brood 2 was the result of hand-pairing a male from a wild-collected cocoon from Berkeley Co., S.C. and a reared female from Pine Grove, Schuylkill Co., Pennsylvania. Larvae were fed tuliptree.

Brood 3 resulted from a natural pairing in a cage between a male from the same source as the others and a female from Pine Grove, PA from a wild-collected cocoon. Mortality in this brood occurred during the larval stadia.

Larva (Fig. 1): Color bluish as in pure *C. promethea*, but most with pale lateral stripes. Red and yellow scoli large, either weakly clavate or tapered toward apex, in a few individuals some of these scoli bifid. Two larvae in Brood 1 were supertuberculate (see Peigler, 1977).

Cocoon: Most with well-developed attachments to stem. Color brownish-gray to brilliant gold. Exhibiting considerable variation yet mostly intermediate between parent species.

Male (Fig. 2): Characters of pure *C. promethea* very dominant, having very dark ground color and only minimal gold suffusion beyond postmedian line. Most with a trace of discal mark in forewing, not in hindwing. Underside more intermediate but traits of *C. promethea* still predominating. Wing apices generally more falcate (pointed) than males of either parent species. Some specimens with sparse scaling on thorax and abdomen.

Female (Fig. 3): Antennae and spiracular pattern intermediate. Color in most specimens reddish like *C. promethea* but lighter, some almost orange. Very pronounced black along postmedian line and around discal marks, as in *C. promethea*, but with even more contrast with adjacent areas. Underside quite intermediate, not dissimilar to pure *C. angulifera!* Some of these are larger than any females, hybrid or purebred, in the genus which I have seen—the proverbial heterosis.

C. [angulifera  $\sigma$  X (angulifera  $\sigma$  X securifera  $\varphi$ ) $\varphi$ ] $\sigma$  X C. securifera  $\varphi$ 

All *C. angulifera* stock originated at Clemson, Pickens Co., S.C. and *C. securifera* stock at Berkeley Co., S.C. and after hand-pairing, the female laid 110 ova, of which six hatched. One larva was reared on tuliptree to the pupal stage and a female emerged in July. She was mated to a male *C. angulifera* but the ova did not hatch.

Larva: The yellowish lateral stripe prominent. Colored scoli (red anterior ones, yellow caudal one) very small. Black scoli so minute as to be almost invisible.

Cocoon: Large and puffy as in pure *C. securifera*, having a long, thin peduncle. Color of silk very golden.

Female: Color light orange. Very close to pure *C. securifera* on upperand undersides. Discal marks in all four wings large, more as in *C. angulifera*.

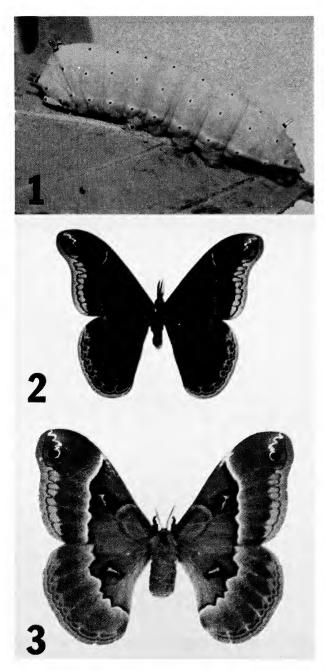


Fig. 1. Mature larva of Callosamia securifera ♂ X C. promethea ♀ from Brood 2. (Coloration in figure is too blue).

Fig. 2. Hybrid male of C. securifera  $\circ$  X C. promethea  $\circ$  from Brood 2.

Fig. 3. Hybrid female of C. securifera  $\circ$  X C. promethea  $\circ$  from Brood 1. (Coloration of actual specimen is more orange).

#### Conclusions from Above Crosses

The larvae of the three broods of C. securifera  $\circ$  X C. promethea  $\circ$  were all intermediate between parent species but exhibited pronounced differences between each brood (larvae of the pure species are rather constant). Larvae within a single brood showed minimal variation among themselves. Thus, each time a particular cross is repeated, one can expect similar but not identical results.

One of the conclusions from my earlier experiments (Peigler, 1977) was that hybrids involving C. promethea are sterile, i.e., cannot be backcrossed or make  $F_2$  crosses. Due to different emergence dates for males and females and my being away when they emerged, I was unable to test the fertility of these moths by additional matings. Earlier crosses of C. promethea with the two other species failed to show two larval characters, which appeared in the new cross. One of these traits is the presence of a light lateral stripe, and the other is the whitish ring on the four red thoracic scoli just above the black bases. These two features can be seen clearly in the color photograph (Fig. 1) of one of the larvae, which could otherwise pass for pure C. promethea.

The three broods of the cross C. securifera  $\circlearrowleft$  X C. promethea  $\circlearrowleft$  gave similar results despite the fact that in one the female was from the South (from a population sympatric with C. securifera) and in the other two the females were from Pennsylvania (allopatric to C. securifera). This suggests that geographical genetic variation may be overshadowed by interspecific genetic differences. Many additional crosses are needed to develop such conclusions. Source localities of parental stock in hybridization studies should always be recorded.

The complex cross described above involving C. angulifera and C. securifera gave evidence that a small amount of fertility can be retained in hybrids for at least three generations, notwithstanding the fact that eclosion becomes very low already in the first backcross or  $F_2$  cross (this is item 7 on Table 2), as also shown in some of my earlier crosses. This sterility occurs even when the ovipositing female is purebred.

As I pointed out (Peigler, 1977), most mortality in hybrid broods occurs in very young larvae, suggesting a genetically based physiological disharmony. Because of the ever-present problem of disease, and the fact that broods of the pure species also suffer from the same, such "negative data" cannot be very useful. I have no quantitative data available for percent success in rearing the three pure species from eggs to adults, but the usual results are normally no better than in the F<sub>1</sub> hybrid broods. Workers using *Drosophila*, certain plants, etc. enjoy higher numbers of experimental subjects on which to make statistical analyses. My methods of recording and tabulating data from the hybridization experiments follow those prescribed by Robinson (1971) in the introductory chapter of his book. A summary of results of all F<sub>1</sub> crosses I have made thus far is given in Table 1.

#### **Isolating Mechanisms**

Collins and Tuskes (1979) provided a definitive study of isolating mechanisms in another genus of saturniid moths, but these were predominantly prezygotic, and postzygotic ones such as reported here are desirable to complete their study. The present study of *Callosamia* would be enhanced by prezygotic observations such as theirs. I have attracted males of *C. angulifera* and *C. securifera* to captive females of *C. promethea* which were emitting pheromone during the flight times of the other two species. To determine whether pheromone differences exist between the three species will require observations such as those of Collins and Tuskes (1979).

Priesner (1968) gave data to suggest that the pheromone of all three species of *Callosamia* may be the same, and demonstrated that *Hyalophora cecropia* (L.) and *C. promethea* have different pheromones, but there is a partial degree of interattractivity. Rau and Rau (1929) reported a male of *C. promethea* attracted to a female of *H. cecropia* which emitted pheromone at the normal time before dawn.

Harbich (1976) presented an array of postzygotic isolating mechanisms in sphingid moths remarkably parallel to those of *Callosamia*. General classifications of reproductive isolating mechanisms were tabulated by Dobzhansky (1970) and Littlejohn (1969). My Table 2 roughly follows the format of the latter, but is modified to fit *Callosamia* in particular.

In nature each of the isolating mechanisms enumerated in Table 2 are tested if the previous one fails. In captivity only items 1a and 2 can be circumvented by artificial methods, and we may assume that temporal isolation is probably the most important one operating in nature. Selection should be expected toward those highest on the list (Littlejohn, 1969). In Callosamia crosses it is possible to see examples of all isolating mechanisms in Table 2 excepting item 2. Even this one could be tested by placing captive females in large cages with a choice of plants for oviposition.

I am not aware of any valid reports of wild hybrids ever being found, but private and museum collections should be checked nonetheless. The erroneous report of a C. promethea-C. angulifera wild hybrid in the News of the Lepidopterists' Society (June 1975, p. 10) was based on the erroneous statement that these hybrids occur by Collins and Weast (1961). Although the artificial hybrids of known parentage are recognizable as having intermediate or combined traits, wild hybrids could be easily overlooked unless a search with the explicit intention of finding them was undertaken. The searcher must be familiar with the normal variation which occurs within each species. If the three species of Callosamia can be crossed so easily in captivity, surely the primary isolating mechanisms must occasionally fail in nature. Examples of how this could occur include the possibility of artificial lights (such as streetlights) causing a female of C. promethea to continue emitting pheromone after nightfall, thus attracting

Table 1: RESULTS OF BASIC F1 CROSSES IN CALLOSAMIA\*

CROSS	No. eggs eclosed/ no. eggs deposited	No. pupating	No. ♂	<b>No.</b> ♀	fast-slow ♀♀ development
angulifera ♂ X promethea ♀		33	19	14	fast ♀♀
angulifera ♂ X promethea ♀	6/115	2	1	1	
angulifera ♂ X securifera ♀	ca. 125/150	56	~ 25	28	fast ♀♀
angulifera ♂ X securifera ♀	14/17	12	7	4	
promethea ♂ X securifera ♀	155/175	ca. 20**	4	0	
promethea ♂ X securifera ♀	109 + /235	31	23	8	slow ♀♀
securifera ♂ X promethea ♀	125/134	10	6	4	slow ♀♀
securifera ♂ X promethea ♀	almost 100% eclosion	32	19	13	slow ♀♀
securifera ♂ X promethea ♀	almost 100% eclosion	15	9	6	slow ♀♀
securifera ♂ X angulifera ♀	21/128	12	6	5	slow ♀♀
angulifera ♂ X Samia cynthia ♀	over 90% eclosion	10	4	0	

<sup>\*</sup>Including results from Peigler (1977 and 1978).

Note: The only basic F<sub>1</sub> cross combination which I have not had the opportunity to make is promethea & X angulifera Q.

Table 2: ISOLATING MECHANISMS IN CALLOSAMIA

- 1. Reduction or elimination of cross-mating
  - Temporal
  - Mechanical
- 2. Incorrect or poor choice of foodplant for oviposition
- Zygotic mortality—eggs fail to hatch
- 4. Weak F1 progeny
  - a. Larval inviability
  - b. Disruptive diapause of pupa (see Peigler, 1978)
  - Adults not vigorous or well-formed (see Peigler, 1977)
- Differing developmental times for female hybrids
- Incorrect temporal activity of hybrid adults
- 7. F1 hybrid or backcross sterility—partial or complete

Note: Mechanism 1a is premating, 1b-7 are postmating; 1-2 are prezygotic, 3-7 are postzygotic

<sup>\*\*</sup>Less than half pupated within the 55 cocoons which were spun.

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males of *C. angulifera*. Even if the situation just proposed were to occur, it would be additionally necessary for the female to have failed to mate with a male of *C. promethea* earlier, which is also unlikely. Another possibility for cross matings is the emergence of females of two species in close proximity (within several cm), and males mating with both when attracted to the first "calling" female.

Circadian temporal isolation (allochronic mating behavior) in *Callosamia* was finally clarified by Ferguson (1972). Stated simply, *C. securifera* flies (i.e., females emit pheromone and males respond) during midday hours, *C. promethea* flies in late afternoon, and *C. angulifera* flies after sundown but before midnight. Supposedly a margin of one hour or more falls between these flight times when no species is flying. Male and female F<sub>1</sub> hybrids of *Callosamia* are possibly at a disadvantage for timing of correct mating behavior (item 5 on Table 2). Some data for this are in Peigler (1977).

One area of worthwhile investigation would be comparison of exact flight times of all three species of Callosamia between sympatric and allopatric populations. Specifically, would C. promethea fly earlier and/or later in Cedar Rapids, Iowa where it is common but the other two species do not occur, than populations of C. promethea living among its congeners? Indeed Ferguson (1972) stated that C. securifera flies earlier in coastal South Carolina (sympatric with C. promethea) than in south-central Florida (allopatric to C. promethea). The flight times of these two diurnal species probably vary with atmospheric conditions (Collins and Weast, 1961), with population density (low population levels perhaps having a broader flight time to ensure all females are mated), and with latitude, since photoperiod varies with the latter. Lepidopterists in several states could make useful contributions by keeping careful and persistent records on the circadian behavior of these moths, and noting the aforementioned parameters. Some data are already in place (Rau and Rau, 1929; Toliver et al., 1979). There appears to be no seasonal temporal isolation in Callosamia, as was given by Ferguson (1972) for two species of Hyalophora in southeastern Canada.

Mechanical isolation (incompatibility of genitalia) is virtually negligible between *C. securifera* and *C. angulifera*, but *C. promethea* has considerably larger genitalia in both sexes than its congeners. Should we then be surprised that the flight time of *C. promethea* falls between the other two? Shapiro (1978) and Dobzhansky (1970) gave some convincing arguments against the "lock and key" significance, but I believe that mechanical differences in *Callosamia* do play a role in reducing natural hybridization. I have discussed (Peigler, 1977 and 1978) how this difference also hinders artificial hybridization experiments. Male genitalia of the hybrids are intermediate in size and shape.

Information on foodplant specificity in this genus can be found elsewhere (Ferguson, 1972; Peigler, 1976; Feeny and Scriber, 1979).

Since tuliptree is known to be the best foodplant for hybrids, ovipositing females of C. promethea which had mated to one of the other species would likely select plants unsuitable for the hybrid larvae, since C. promethea is polyphagous. A female of C. securifera would oviposit on sweetbay, although tuliptree would be a better host for her offspring if she had mated to a nonconspecific male. Brood 1 of the cross C. securifera & X C. promethea  $\mathcal{P}$  included a striking difference in size of adults between those reared on tuliptree and those on sweetbay. Slower growth rates were also seen when rearing on sweetbay the larvae of C. angulifera & X C. securifera ♀ (Peigler, 1976). It is possible that tuliptree is the best foodplant for pure C. promethea, as shown by certain growth data given by Feeny and Scriber (1979). Since C. angulifera is monophagous on tuliptree, the foodplant difficulty would not occur in wild hybrid broods in which the mother was C. angulifera. An F<sub>1</sub> hybrid female of any given parentage in the genus may be no more likely to select the best foodplant (tuliptree) than a less optimal one. Such foodplant differences in closely related species of Lepidoptera can certainly be interpreted as an isolating mechanism.

Female hybrids showing both heterosis (as I mentioned under the cross C. securifera of X C. promethea Q) and reduced viability (as I mentioned under C. promethea ♂ X C. securifera ♀ in Peigler (1977)) were obtained in crosses of the genus Colias (Pieridae) by Grula and Taylor (1980). The latter authors attributed these differences between sexes in hybrid broods and between reciprocal crosses to the X-chromosome, which apparently contains most or all genes governing size, developmental rate, wing pigmentation, and wing color pattern. Callosamia has not been investigated cytogenetically, except for spermatogenesis in C. promethea (Robinson, 1971). Moths in the same subfamily (Saturniinae) as Callosamia may have the XXJ:XYP or XXJ:XOP type of sex determination, the presence of sex chromatin seemingly correlated with the latter (Gupta and Narang, 1980). It would be best to reserve speculation about the genetic implications of results from crosses within this genus until such basic cytogenetic information is available. Haldane's Rule (Robinson, 1971: 24; Dobzhansky, 1970: 333) that the heterogametic sex is rarer or has reduced viability in hybrid broods certainly appears to hold for Callosamia. The pronounced sexual dimorphism of these moths will make such studies all the more enticing, since the findings of Grula and Taylor (1980) suggest increased sexual dimorphism connotes increased genetic incompatibility in hybridization of Lepidoptera.

A conspicuous phenomenon which is well-illustrated by *Callosamia* hybrids is that of males emerging before or after females of a hybrid brood, frequently the females diapause and the males do not (see Table 1). This was also shown by Cocault *et al.* (1980) in a hybrid brood of the saturniids *Graellsia isabellae* (Graells) of X *Actias luna* (L.) Q. Oliver (1978 and 1979) found the phenomenon in his nymphalid hybrids as did Grula and Taylor

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(1980) in their hybrids of *Colias*. The differing developmental rates of the sexes in hybrid Lepidoptera are here proposed as an isolating mechanism (item 5 in Table 2) because such would reduce frequency of  $F_2$  and backcross matings when hybrid broods are produced in nature. Based on the few  $F_1$  crosses made thus far in *Callosamia*, it appears that fast female development occurs in hybrid broods in which the father is *C. angulifera*, and slow female development is to be expected in broods fathered by *C. securifera* or *C. promethea*.

#### Discussion

Some workers have advocated that isolating mechanisms are the result of speciation, not the cause (Ehrlich and Raven, 1969) while others appear to take the opposing viewpoint (e.g., Bush, 1969). Lewontin (1974: 161) felt that isolating mechanisms arise as a result of genetic divergence due to allopatry, and then become selectively reinforced upon secondary contact. These matters were also ably reviewed by Futuyma and Mayer (1980) who concluded that the genetic and selective causes of reproductive isolation are still largely unknown. In Callosamia I would propose that the large amount of genetic incompatibility inferred from the hybrid crosses is strong evidence that the genomes of the three species differ considerably, but allozyme analysis would be desirable as proof. These and other isolating mechanisms were probably increased in number and intensity after speciation was complete. Once allochronic mating behavior became perfected (whatever the cause) to the point that cross matings were no longer significant in number, the other mechanisms would increase in number and intensity due to genetic divergence, the three species then being on separate paths of evolution. The postzygotic ones cannot be assumed, in my opinion, to have evolved to be relied upon when the prezygotic ones failed. They are merely coincidental, but are to be considered valid isolating mechanisms in that they reduce chances of hybrids being produced, or when produced will fail to pollute the genomes of the pure species. Although the evolutionary processes which result in speciation and in reproductive isolation are still poorly understood, the two processes must evidently go hand-in-hand to the extent that one is not necessarily the result of the other.

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### Canalization of the Phenotype of Nymphalis antiopa (Lepidoptera: Nymphalidae) from Subarctic and Montane Climates

Arthur M. Shapiro

Department of Zoology, University of California, Davis, California 95616

Abstract. Nymphalis antiopa from the montane Sierra Nevada of California respond phenotypically to pupal cold shock in a manner similar to lowland California antiopa and unlike subspecies hyperborea from Alaska. This could result from historical factors, gene flow, or canalization of the phenotype in the Sierran climate, which shows very wide diel temperature fluctuations but not the prolonged cool spells common in the Alaskan summer.

The concept of canalization of development (Waddington, 1957) has been thoroughly assimilated into the evolutionary framework of modern biology. Like many other biological concepts deriving from seemingly impregnable Darwinian deduction, it has rarely been tested experimentally; although physiological adjustment in geographic populations is routinely demonstrated, developmental buffering is not. Shapiro (1981) attempted to test the hypothesis that canalization is adaptive to the physical environment, using the phenotypic response of the Mourning Cloak butterfly, Nymphalis antiopa (Linnaeus) to pupal cold shock. It has been known for over a century that various species of the tribe Nymphalini respond to temperature shock by producing predictable, often very radical, pattern aberrations. In the most dramatic aberration of N. antiopa, "hygiaea," the yellow border is doubled in width, and the blue spots normally arranged in a row basad of it are entirely absent (Fig. 1). "Hygiaea" can be induced by a variety of treatments (Fischer, 1907; Standfuss, 1896). One treatment which is very efficacious at inducing it in near-sea-level Californian stock is exposure of 8-hr-old pupae to 2°C for 2 weeks. Shapiro (1981) reasoned that the subarctic subspecies N. a. hyperborea (Seitz), which has a relatively high probability of being chilled in the pupal stage, should be better buffered developmentally against cold than lowland Californian N. a. antiopa, which are assured of benign conditions in a Mediterranean climate. Treatment failed to produce any "hygiaea" among 53 Alaskan animals, vs. 31 among 157 lowland Californian ones. This is a highly significant difference ( $\mathbf{z}^2 = 12.28$ , p <0.005). Limitations on the interpretation of these results are spelled out by Shapiro (1981).

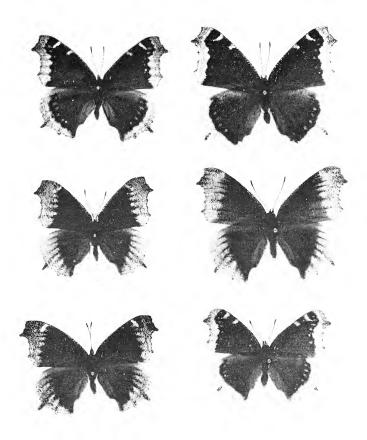


Fig. 1. Bred, cold-shocked Nymphalis antiopa. Left: Donner Pass, Sierra Nevada, normal (top) and "hygiaea" (center, brood 3; bottom, brood 4). Right: Vacaville, Solano County, lowland California, normal (top) and "hygiaea" (center); ssp. hyperborea, Fairbanks, Alaska, 1979 (bottom).

N. antiopa occurs in California from sea-level to tree-line. Populations at high altitudes, like Alaskan ones, are likely to be chilled during development. The pattern of probable exposure differs radically between the two areas, however. Alaskan hyperborea are larvae in June-early July and pupae in mid-July (Fairbanks). They are likely to experience periods of cool, showery weather with temperatures between 40-50°F), but no frost. Such weather is almost impossible in the Sierra Nevada of California. At 7000 ft. (2100+m), antiopa are larvae in late July-early August, and pupae in mid-August. Afternoons are clear to partly cloudy with frequent highs of

 $80^{\circ}F$  (27°C), but nocturnal freezes are very common. Thus, Alaskan antiopa may develop in prolonged cool but not cold conditions, while Sierran ones are cold almost every night but warm almost every day. Summer monthly mean temperatures for Fairbanks, Alaska and Truckee, California are similar, but the diel ranges are very different (Tables 1, 2). Since short exposures (less than 1 wk) to 2°C have little or no phenotypic effect on N. antiopa, and the full 2-wk exposure is required to obtain the full expression of "hygiaea," it would not be surprising if Sierran antiopa were less well buffered against sustained low temperatures than Fairbanks hyperborea. This was tested experimentally in 1980.

Five colonies of larvae were collected in the 3rd instar on willows (Salix spp.) at two Sierran localities: one from Martis Creek, near Truckee, Placer Co. (elevation about 5600 ft. = 1707 m), July 5, 1980, and four from the east end of Donner Pass along U. S. Highway 40 east of Norden, Placer Co. (7000 ft. = 2134 m), August 7, 1980. Martis Creek is a sedgy swale

**Table 1.** Comparisons of summer temperatures for Fairbanks, Alaska and Truckee, California for a sample year (1977). Data from National Oceanic and Atmospheric Administration, Asheville, N. C.

#### VALUES IN °F AND (IN PARENTHESES) °C

	F	airbank	$\mathbf{S}^1$		Trucke	e²
Variable	June 77	July 77	Aug. 77	June 77	July 77	Aug. 77
mean daily maximum	68.8 (20.4)	73.7 (23.1)	73.2 (22.9)	77.4 (25.2)	80.7 (27.0)	81.6 (27.5)
mean daily minimum	50.4 (10.2)	51.9 (11.0)	52.0 (11.1)	42.1 (5.6)	41.8 ( 5.4)	44.5 ( 6.9)
mean daily temperature	59.6 (15.3)	62.8 $(17.1)$	62.6 (17.0)	59.8 (15.4)	61.3 (16.3)	63.1 (17.3)
departure of mean daily T from long-range mean daily T	+0.6 (+0.3)	+2.1 (+1.2)	+7.2 (+4.0)	+6.3 (+3.5)	0 0	+3.4 (+1.9)
number of nights with temperature below 40°F (4.4°C)	0	0	2	10	12	6

<sup>1</sup>Fairbanks Airport, 64°49′ N, 147°52′ W, elevation 436 ft. = 182.9 m. <sup>2</sup>Truckee Ranger Station, 39°20′ N, 120°11′ W, elevation 5995 ft. = 1827.3 m.

Table 2. Freeze data for Fairbanks, Alaska and Truckee, California. Station data as in Table 1. Source: NOAA.

D.	ATE OF LAST S	SPRING OC	CURRENC	E OF:	
	16°F (-8.9°C)	20° (-6.7)	24° (-4.4)	28° (-2.2)	32° (0)
Fairbanks 1977	16.IV	29.IV	29.IV	29.IV	10.V
Truckee 1977	19.V	19.V	28.V	29.V	11.VI
Γ	OATE OF FIRST	FALL OCC	CURRENCE	OF:	
	32°F (0°C)	28° (-2.2)	24° (-4.4)	20° (-6.7)	16° (-8.9)
Fairbanks 1977	$4.\mathrm{IX}$	1.X	1.X	13.X	16.X
Truckee 1977	5.VII	21.IX	$22.\mathrm{IX}$	7.XI	9.XI
NUMBEF	R OF DAYS BET FALL O	WEEN LAS		AND FIRS	${ m ST}$
	16° (-8.9)	20° (-6.7)	24° (-4.4)	28° (-2.2)	32° (0)
Fairbanks 1977	183	167	155	155	117
Truckee 1977	174	172	117	115	24

running through Great Basin shrub desert (Artemisia, Purshia). The Donner site is mesic-montane and receives a very heavy winter snowpack. Both populations are univoltine. The two sites are about 12 mi (19.3 km) apart. Martis Creek receives cold air drainage at night and is both hotter by day and colder by night than Donner Pass. Truckee Ranger Station (5995 ft. = 1827 m) provides a weather station intermediate in climate and elevation between them.

The Martis Creek colony was reared to maturity on English Elm, *Ulmus procera* (Ulmaceae). This tree became unavailable by August due to defoliation by beetle larvae, and the four Donner broods were reared instead on Hackberry, *Celtis sinensis* (Ulmaceae). All rearing was under continuous light at 25°C. Eight-hr pupae were refrigerated in the dark at 2°C, held for 14 days, and returned to 25°C. Larval mortality was negligible in all broods.

Pupal mortality was very heavy in refrigerated groups from all broods, and exceeded 75% overall. Such heavy mortality is unusual. Moreover, chilled animals usually die as pharate adults, which can be scored for phenotype; in these broods most mortality occurred before wing pigmentation was laid down. *Celtis* is an unusual host, but the very poor survivorship of the Martis Creek brood, reared on *Ulmus*, argues against it as a major cause of pupal mortality; it seems that Sierran *antiopa* are poorly protected physiologically against long chilling in the pupa, even compared to lowland Californian ones.

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#### Results and Discussion

Phenotypic sensitivity paralleled pupal mortality: seven "hygiaea" were produced among 61 scorable Donner animnals (Table 3). This is not significantly different from 31/157 from lowland California ( $\chi^2 = 1.72$ , 0.250 > p > 0.100) but is more unlike 0/53 from Alaska ( $\chi^2 = 6.23$ , 0.025 > p > 0.010). Most suggestively, all four Donner broods gave at least one "hygiaea" each, just as 12/13 lowland Californian broods reared in past years have done. Neither of the 1979 Alaskan broods produced even one individual transitional to "hygiaea." The very small Martis Creek emergence does not significantly affect the statistical comparisons.

Alaskan hyperborea exaggerate their subspecific characters when chilled. The same modifications were seen in both Martis and Donner antiopa. They were often quite marked in animals scored "normal" for purposes of this analysis. Sierran animalss also resembled Alaskan ones in size (mean LFW: lowland CA, 37 mm; Sierra Nevada, 30.3 mm; Fairbanks, 29.0 mm). Unlike hyperborea, Sierran experimentals often showed slight modifications in the direction of "hygiaea"; almost all of Donner brood 3 showed them. Several other odd phenotypes were obtained in the chilled Sierran antiopa: one animal each in Donner 1 and Martis had the wings thinly scaled, and the Martis individual also had the blue spots oddly shaped and arranged, and of a violet color. One individual in Donner 2 had the hindwings symmetrically falcate.

This variability in chilled Sierran antiopa contrasts with both the unchilled controls and with wild-collected material. In a series of about 3 dozen from Donner Pass, Truckee, and nearby Sagehen Creek the phenotype is quite uniform: the size is larger (mean LFW 34.5 mm), there is a slight increase in black in the borders relative to lowland specimens, and the blue spots may be slightly enlarged, especially on the hindwing. The increased black scaling in the borders is duplicated in both control and experimental Sierran broods, increased in the latter. Certain other temperature treatments favor increased blue spotting in both European (Standfuss, 1896) and lowland Californian (Shapiro, unpublished) antiopa.

Sierran antiopa thus behave like lowland Californian ones with respect to the major aberration "hygiaea," but in other responses to chilling they are intermediate in response between lowland Californian and Alaskan broods, and more variable than either. The "hygiaea" response can be accounted for in at least three ways. Two of these imply lack of adaptation to local climate: phylogenetic inertia (recent common ancestry of lowland and Sierran antiopa) and gene flow (constant or intermittent). There are no data bearing directly on either. The species is highly dispersive, and occurs locally from the coast across the Sierra in riparian habitats. Differences in the phenotypes of chilled lowland and Sierran animals argue for some degree of differentiation among the populations. The third hypothesis specifically invokes local climatic adaptation. The dissimilarity

**Table 3.** Results of temperature-shock experiments with *Nymphalis antiopa* from the Sierra Nevada of California.

	Normal	Normal			Unscorable	
Brood, source	live	dead	live	dead	dead	Total
Donner Pass #1						
experimental	18	0	1	0	53	72
control	10	0	0	0	0	10
Donner Pass #2						
experimental	18	1	2	1	45	67
control	10	0	0	0	0	10
Donner Pass #3						
experimental	$14^{1}$	1	2	0	57	74
control	10	0	0	0	0	10
Donner Pass #4						
experimental	2	0	1	0	23	26
control	8	0	0	0	2	10
Martis Creek						
experimental	2²	4	0	0	11	17
control	5	0	0	0	0	5
Totals						
experimental	54	6	6	1	189	256
control	43	0	0	0	2	45
Total Reared:						301

<sup>1</sup>most individuals show definite "hygiaea" tendencies.

of Alaskan and Sierran animals could reflect the different temperature regimes and local adaptation to them, but until considerably more is known of the ecology and genetics of this butterfly it is not possible to distinguish among these three hypotheses. Despite its abundance, the Mourning Cloak is rather poorly known biologically (Young, 1980).

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<sup>&</sup>lt;sup>2</sup>includes one thinly scaled and otherwise aberrant animal (see text).

#### **Aberrant New Mexican Butterflies**

#### Richard Holland

1625 Roma, N.E., Albuquerque, New Mexico 87106, USA

Abstract. Photographs of aberrant Plebejus acmon texanus, Euphilotes rita rita, Speyria atlantis dorothea, Phyciodes campestris camillus, Strymon melinus franki, Thessalia theona thekla, Eyphydryas anicia alena and Hesperia pahaska pahaska are shown. Limenitis astyanax arizonensis ab. doudorffi is illustrated and discussed as an arizonensis X L. weidemeyerii angustifascia hybrid.

Over the 18 seasons (1964-1981) I have collected in New Mexico (Holland, 1974), it is inevitable I would encounter a number of aberrant specimens. The purpose of this article is to illustrate the more unusual New Mexican forms collected.

Figure 1 shows a male *Plebejus acmon texanus* Goodpasture with radically abnormal black markings on the ventral wing surfaces. This specimen was taken at a moist spot in a shady side canyon near Mayhill, NM, at the confluence of Cox Canyon and Wills Canyon. The dorsal surface of this specimen is normal. A number of other small blues were present at this same moist spot; when they were disturbed and took flight, the illustrated specimen immediately gave an appearance quite different from anything in my previous experience. A typical specimen is shown for comparison in Figure 1.

Figure 2 illustrates a normal female Euphilotes rita rita (B. & McD.) and a specimen with the ventral forewing (VFW) postmedial black spots in cells M1 and M2 markedly displaced distally so they fuse with the submarginal spots. The two specimens in Figure 2 were taken in a series of 20 (1000 and 1099); none of the others exhibited the displaced postmedian spots. The abnormality of the specimen in Figure 2 was not apparent until after capture. The dorsal surface of this specimen is normal. Leeuw (1979) has recently figured a specimen of Satyrium acadica acadica (Edwards) which is remarkably similar to the aberrant P. acmon texanus shown here in Figure 1. On the basis of three examples in three different species, one could speculate that lycaenids may have a tendancy towards atypical expression of the postmedial and submarginal spots ventrally.

Figure 3 illustrates male and female Speyeria atlantis dorothea Moeck which show grossly enlarged silvering of the basal part of the ventral

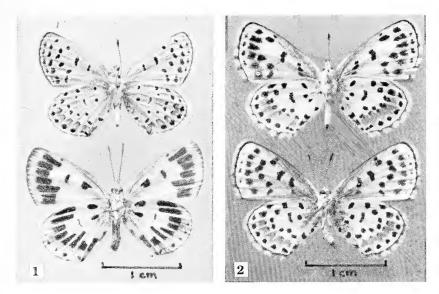


Fig. 1. Plebejus acmon texanus ventral surface: Top, normal & 27 Aug. 75, Curtis Canyon Dam, Sacramento Mts., nr. Mayhill, Otero Co., NM, 6600' (2000 m), leg. R. Holland. Bottom, aberrant & 20 May 75, confluence of Cox Canyon and Wills Canyon, Sacramento Mts., nr. Mayhill, Otero Co., NM, 6500' (2000 m), leg. R. Holland.

Fig. 2. Euphilotes rita rita ventral surfaces:
Top, aberrant ♀.
Bottom, normal ♀, both specimens 1 Sept. 80, 1 mi. E. of Organ, San Augustin Pass, Organ Mts., Dona Ana Co., NM, 5500′ (1650 m), leg. R. Holland & J. McCaffrey.

hindwing (VHW). This figure also shows normal specimens for comparison. The aberrant specimens were taken 14 days and five miles (eight km) apart. It is thus doubtful, but not impossible, they were from the same brood. Of some 50 other dorothea taken during 1966-68 on Mt. Taylor, NM, no other aberrant examples appeared, nor have I ever seen a similarly silvered atlantis (Edwards) of any subspecies from elsewhere. Due to the double occurrence of this aberration, it is tempting to attribute its cause to some recessive allele which is present with very low frequency in the Mt. Taylor population of dorothea. In flight, such specimens were not distinguishably abnormal, nor are their dorsal surfaces.

Figures 4 and 5 show what is probably an extreme melanic of *Phyciodes campestris camillus* Edwards, although the specimen may be *Phyciodes mylitta arizonensis* Bauer. (Both species were present in numbers at the time and place that this specimen was captured.) Note that even the

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forewing shape is abnormal. Instead of having the usual convex or straight outer margin, this specimen has the margin slightly concave at Cu<sub>1</sub>. The specimen is a male. A normal *P. campestris camillus* is also shown in these figures.

Figures 4 and 5 also show a normal male Strymon melinus franki Field and a male of the form which has been called meinersi Gunder. In this form, the normally orange-red "thecla spot" in cell Cu<sub>2</sub> on both surfaces of the hindwing is pale yellow. The usual orange-red marking at the anal angle is also pale yellow, as well as reduced in area. (In the specimen illustrated, a part of the anal angle has been lost from both wings, especially the right.)

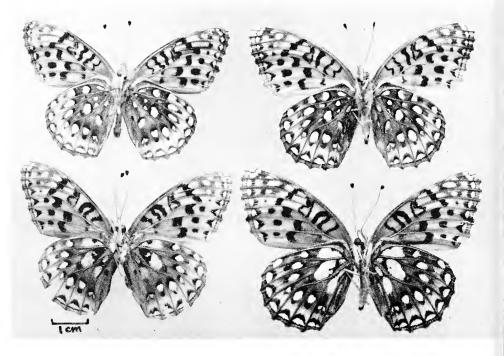
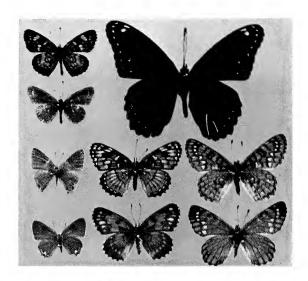
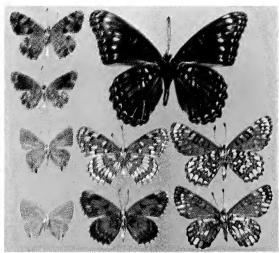


Fig. 3. Speyeria atlantis dorothea ventral surfaces: Top left, normal σ, 19 July 68, 1 mi. S. of La Mosca Outlook, Mt. Taylor, Valencia Co., NM, 10,300' (3150 m), leg. R. Holland. Top right, normal Ω, 16 July 66, San Mateo Spr., San Mateo Canyon, Mt. Taylor, Valencia Co., NM, 8800' (2700 m), leg. R. Holland. Bottom left, aberrant σ, 30 July 66, Tapia Canyon, Mt. Taylor, Valencia Co., NM, 9300' (2850 m), leg. R. Holland. Bottom right, aberrant Ω, 16 July 66, La Mosca Canyon, Mt. Taylor, Valencia Co., NM, 9800' (3000 m), leg. R. Holland.





Left next to bottom, normal &, Strymon melinus franki, 30 July 68, 2 mi. S. of New Canyon C. G., Manzano Mts., Torrance Co., NM, 7400' (2250 m). Bottom left, aberration meinersi &, Strymon melinus franki, 3 mi. W. of Sanostee, Chuska Mts., San Juan Co., NM, 5500' (1650 m).

Oddly, the *meinersi* specimen has the postmedian band inwardly suffused with the normal *melinus* (Huebner) orange-red on the VHW, although the amount of suffusion is greatly reduced. The VFW postmedian line suffusion on the *meinersi* specimen is completely absent. Similarly, the *meinersi* specimen has the tip of the antenna club a normal *melinus* orange-red.

In addition to the figured specimen, I have a female *meinersi* taken in poor condition at New Canyon, 7400' (2300 m), Manzano Mts., Torrance Co., NM, 30 July 68, leg. R. Holland. Normal *melinus* may have the abdomen either grey or with the last four segments orange-red. The figured *meinersi* has a grey abdomen; the unfigured *meinersi* has the last four abdominal segments dorsally white.

In April, 1974, at Alamo Canyon, near Alamogordo, NM, there was a great population explosion of *Thessalia theona thekla* (Edwards). Figures 4 and 5 also show a female taken at this time with the normal theona (Menetries) pattern almost completely obliterated. The normal form is also illustrated. The complete brown occlusion of the normal VHW basal, medial and marginal pearlish bands is especially striking. The marginal pearlish band normally present on the VFW is similarly occluded. Typically, the dorsal surface of theona thekla is tricolored: chocolate, light fulvous and dark fulvous, with each color fairly sharply delineated. In the aberrant specimen, the chocolate and dark fulvous are not at all sharply delineated, and the light fulvous is completely absent except for a row of submarginal smudges on the forewing. The usual ventral theona thekla pattern is also tricolored: chocolate, dark fulvous and pearl, with the pearl bands sharply set off into rectangular spots by chocolate scaling on the veins. In this specimen, however, there is almost no pearl ventrally, and certainly no hint of chocolate scaling on the veins. In normal theona thekla, the ventral surface is not a particularly close replica of the dorsal surface. However, the two surfaces are quite alike in this aberration. No other theona thekla aberrations were seen in this population explosion.

Figures 4 and 5 additionally illustrate a female Euphydryas anicia alena Barnes & Benjamin with the following abnormalities: the apex of both surfaces of the forewings are unusually blackened; the usual transverse basal and discal DFW and DHW black markings are absent; and the medial and basal markings of the VHW are peculiar in having elongated pearly spots, especially in cells SC and Cu2. Euphydryas species in general appear to produce more frequent aberrant individuals than most other genera, e.g., the forms figured in Comstock (1927). Indeed, I have another aberrant alena from the same place. Normal alena is given in this figure as well.

Finally, Figures 4 and 5 illustrate a male of what has been called  $Limenitis\ astyanax\ arizonensis\ ab.\ doudoroffi\ (Gunder)$ . Perkins and Garth (1972) assert that the entity is almost certainly a hybrid between L.  $weidemeyerii\ Edwards\ and\ L.\ astyanax\ (Fabricus)$ .

Neither astyanax nor weidemeyerii are frequently encountered in the Sacramento Mts. of southeastern New Mexico. Small L. astyanax arizonensis colonies exist in at least two riparian canyons (Alamo Canyon and Three Rivers Canyon) on the west slope of this range around 5500 to 6500′ (1700 to 2000 m). The Three Rivers location is also the source of the subject doudoroffi specimen. Limenitis weidemeyerii is even rarer in the Sacramentos; I have a single specimen taken near the summit of Sierra Blanca at 11,000′ (3300 m), about five miles (eight km) from where the subject specimen was captured. The single Sierra Blanca weidemeyerii specimen appears to be ssp. angustifascia (B. & McD.), although Perkins and Perkins (1975) indicate the Sacramento Mts. to be closer to the known range of typical weidemeyerii. (Evidently Perkins and Perkins (1975) had very scant Sacramento Mts. weidemeyerii available. In any event, my single weidemeyerii specimen forms an uncertain basis for determining which subspecies inhabits the Sacramento Mts. so tenaciously.)

Perkins and Garth (1972) illustrate an example of doudoroffi from the Allen Hancock Foundation (AHF), and mention the existence of three other specimens, one in the Los Angeles County Museum (LACM), one taken by Bauer, and the type taken by M. Doudoroff. All four of these specimens are from Arizona, where the weidemeyerii subspecies would unquestionably be angustifascia, the same subspecies which appears to exist in the area where this doudoroffi specimen was taken. The present specimen differs only in very minor ways from that illustrated by Perkins and Garth: On the DFW it has only two, not three or four subapical white spots; and the whitish median band on the VFW anterior to M2 is more expressed.

Perkins and Garth indicate that their doudoroffi specimen, like the one illustrated here, has furruginous scales suffusing the apex of the VFW. They maintain that, in this trait, it resembles astyanax arizonensis, and that in weidemeyerii angustifascia the corresponding suffusion is black. However, my Sierra Blanca weidemeyerii has the area suffused with ferruginous scaling as extensively as the doudoroffi. Indeed, approximately half the weidemeyerri I have seen from New Mexico have at least some ferruginous scaling in this area, although the Sierra Blanca specimen is the most extensively so scaled.

Hybridization among *Limenitis* species is widely documented; see, for example, Shapiro and Biggs (1968), Perkins and Gage (1970), Gage (1970), Hovanitz (1949), Simpson and Pettus (1976), and Platt, Rawson and Balogh (1978). Due to the extreme scarcity of both *weidemeyerii* and *astyanax* in the Sacramento Mts.; it is easy to postulate a female of one species accepting courtship from the most nearly eligible male to be found—even if that male was of the other species. In any event, I am fully convinced that the question mark of Perkins and Garth (1972) can now be removed, and ab. *doudoroffi* can be recognized as a *weidemeyerii* X

astyanax arizonensis hybrid. Such recognition is, of course, without nomenclatorial significance, because aberration and hybrid names do not have code standing.

After the initial submission of this article, a very baffling female Hesperia was captured on the south slope of the Capitan Mts. in Lincoln Co., NM. The entire VHW of this specimen, which is shown in Figure 6, is immaculate—a condition not characteristic of any Hesperia. At the same time and place, Hesperia pahaska pahaska Leussler (common) and H. uncas uncas Edwards (occasional) were flying. Hesperia viridis (Edwards) had been taken nearby earlier in the season. The aberrant specimen was immediately recognizable as peculiar in the field. In fact, I first missed a sitting shot while the insect was nectaring at a thistle. Upon returning to the same thistle four hours later, I was rewarded by finding the striking



# Figure 6

Hesperia pahaska pahaska ventral surfaces:

Top, aberrant pahaska (?) ♀, 26 July 80, Peppin Canyon, S. slope, Capitan Mts., nr. Capitan, Lincoln Co., NM, 7000′ (2150 m), leg. R. Holland.

Middle, intermediate pahaska 9, 14 June 80, road S. of Capitan Gap at National Forest boundary, Capitan Mts., Lincoln Co., NM, 6500' (2000 m), leg. R. Holland.

Bottom, normal pahaska Q, 27 July 80, Pierce Canyon, S. slope Capitan Mts., nr. Capitan, Lincoln Co., NM, 6300' (1900 m), leg. R. Holland. Hesperia had also returned. Later examination of H. p. pahaska from this locality revealed a female specimen with VHW markings greatly reduced, but not completely missing. It is on the basis of this intermediate specimen and the general abundance of pahaska in the area that I concluded the immaculate specimen is probably also pahaska. The intermediate specimen and a typical pahaska female are also illustrated in Figure 6.

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# (continued from page 91)

Upper right, Limenitis astyanax arizonensis aberration doudoroffi = L. weidemeyerii X L. astyanax arizonensis &, 23 June 75, Three Rivers C. G., nr. Carrizozo, Sacramento Mts., Lincoln Co., NM, 6500' (2000m).

Center, normal 9, Thessalia theona thekla, 30 Apr. 74, W. slope of San Augustin Pass, 18 mi. E. of Las Cruces, Organ Mts., Dona Ana Co., NM, c. 5500' (1650 m), leg. G. S. Forbes.

Bottom middle, aberrant  $\mathfrak{P}$ , *Thessalia theona thekla*, 28 Apr. 74, Alamo Canyon, nr. Alamogordo, Sacramento Mtjs., Otero Co., NM, 5500' (1650 m).

Middle right, normal \( \frac{1}{2}, Euphydryas anicia alena, 16 May 76, Grasshopper Spr., nr. Ramah, Zuni Mts., McKinley Co., NM, 7500' (2300 m).

Bottom right, aberration Q, Euphydryas anicia alena, same data as specimen above.

Fig. 5. Ventral surfaces of specimens in Fig. 4.

# Diapause in Various Populations of Pieris napi L. from Different Parts of the British Isles

E. Lees

and

D. M. Archer

Postgraduate School of Biological Sciences, University of Bradford, Bradford, W. Yorks, England

Diapause has been defined (Beck, 1967) as a genetically determined state of suppressed development, the manifestation of which may be induced by environmental factors. It follows, therefore, that different, geographically isolated populations of a butterfly should have different assemblages of genes determining diapause and hence should show a somewhat different diapause response to the same environmental conditions. The phase of development in which *Pieris napi* L. undergoes diapause is the pupal phase. Whether or not an individual undergoes pupal diapause depends in part on the photoperiod and temperature encountered during late larval life (Danilevskii, 1961). This, in turn, determines whether a particular population of the species is monovoltine or polyvoltine. *P. napi* is usually regarded as being partially bivoltine in the British Isles (Lees and Archer, 1974), but this statement hardly does justice to the complex situation which prevails over the country as a whole.

Colonies of *P. napi* which are strictly monovoltine are known (Lees, 1970) and these are usually found at altitudes of 800 feet or more in Northern England and Scotland. Elsewhere in the British Isles the species is at least partially bivoltine or even partially trivoltine. It should be noted, however, that even in those parts of the country where there is a second and third brood, a significant part of the pupae derived from the spring generation are diapause pupae and do not develop into butterflies until the following year.

In order to learn more of the diapause characteristics of *Pieris napi* in different parts of the British Isles, we sampled spring populations of the species from various localities ranging from Teignmouth in S. Devon to Dollar in Scotland, although the majority of samples were from populations in N. England (c.f. Fig. 1). Eggs from the captured females were kept in plastic boxes until they hatched and the resultant larvae were maintained under controlled conditions of photoperiod and temperature until they pupated. The larvae were fed on the leaves of Hedge Garlic (*Alliaria petiolata*), a common foodplant of this species in the field.

The photoperiod chosen for the experiments was 18 hours, which is a "long-day" photoperiod, similar to the daylength of the longest day over much of England. The larvae were reared at two temperatures viz. 18 degrees C and 12 degrees C. The former is similar to the mean maximum of the warmest month in S. England, the latter is similar to the mean maximum of the warmest month at altitudes of 1000 feet in N. England and Scotland. The numbers and percentages of diapause and non-diapause pupae obtained in the various experiments are shown in Tables 1 and 2.

Table 1
Experiments at 18 Hr. Photoperiod and 18 Degrees C

Locality	Elevation (M.)	Offspring of Female	No. of Diapause Pupae Produced Among Progeny	No. of Non-Diapause Pupae Produced Among Progeny
Dollar	48	1	5 (19.2%)	21 (80.8%)
Dollar	48	2	6 (16.6%)	30 (83.4%)
Dollar	48	3	8 (23.5%)	26 (76.5%)
Dollar	48	4	6 (14.0%)	42 (86.0%)
Bellingham	122	1	8 (16.6%)	40 (83.4%)
Bellingham	122	2	6 (14.3%)	36 (85.7%)
Bellingham	122	3	6 ( 8.7%)	39 (91.3%)
Bellingham	122	4	4 (18.2%)	18 (81.8%)
High Force	381	1	7 (15.5%)	38 (84.5%)
High Force	381	2	8 (16.6%)	40 (83.4%)
High Force	381	3	9 (20.9%)	36 (79.1%)
High Force	381	4	4 (16.0%)	21 (84.0%)
Arnside	15	1	6 (17.6%)	38 (82.4%)
Arnside	15	2	2 ( 6.9%)	27 (93.1%)
Arnside	15	3	3 (10.4%)	25 (89.6%)
Strensall	15	1	6 (14.3%)	36 (85.7%)
Strensall	15	2	3 (10.8%)	25 (89.2%)
Strensall	15	3	4 (11.8%)	30 (88.2%)
Strensall	15	4	2 ( 6.6%)	28 (93.4%)
Menston	48	1	3 (13.1%)	20 (86.9%)
Menston	48	2	2 (7.3%)	25 (92.7%)
Menston	48	3	2 ( 8.7%)	23 (91.3%)
Menston	48	4	4 (11.8%)	30 (88.2%)
Nantwich	30	1	2 ( 8.7%)	22 (91.3%)
Nantwich	30	2	1 (4.0%)	24 (96.0%)
Nantwich	30	3	3 (7.9%)	36 (92.1%)
Teignmouth	8	1	2 ( 6.7%)	28 (93.3%)
Teignmouth	8	2	4 (11.8%)	30 (88.2%)
Teignmouth	. 8	3	3 ( 7.7%)	36 (92.3%)
Teignmouth	8	4	2 ( 6.4%)	29 (93.6%)

Table 2

Experiments at 18 Hr. Photoperiod and 12 Degrees C

Locality	Elevation (M.)	Offspring of Female	No. of Diapause Pupae Produced Among Progeny	No. of Non-Diapause Pupae Produced Among Progeny
Dollar	48	1	31 (100%)	0 ( 0.0%)
Dollar	48	2	43 (100%)	0 ( 0.0%)
Dollar	48	3	19 (100%)	0 ( 0.0%)
Dollar	48	4	25 (100%)	0 ( 0.0%)
Bellingham	122	1	23 (100%)	0 ( 0.0%)
Bellingham	122	2	37 (100%)	0 ( 0.0%)
Bellingham	122	3	24 (100%)	0 ( 0.0%)
Bellingham	122	4	36 (100%)	0 ( 0.0%)
High Force	381	1	20 (100%)	0 ( 0.0%)
High Force	381	2	34 (100%)	0 ( 0.0%)
High Force	381	3	31 (100%)	0 ( 0.0%)
High Force	381	4	28 (100%)	0 ( 0.0%)
Arnside	15	1	24 (88.8%)	3 (11.2%)
Arnside	15	2	48 (85.7%)	8 (14.3%)
Arnside	15	3	30 (83.3%)	6 (16.7%)
Arnside	15	4	20 (77.0%)	6 (23.0%)
Strensall	15	1	21 (91.3%)	2 ( 8.7%)
Strensall	15	2	27 (90.0%)	3 (10.0%)
Strensall	15	3	50 (89.4%)	6 (10.6%)
Menston	48	1	22 (84.6%)	4 (15.4%)
Menston	48	2	40 (85.1%)	7 (14.9%)
Menston	48	3	42 (89.4%)	5 (10.6%)
Nantwich	30	1	20 (80.0%)	5 (20.0%)
Nantwich	30	2	37 (83.4%)	7 (16.6%)
Nantwich	30	3	39 (81.4%)	8 (18.6%)
Teignmouth	8	1	29 (82.9%)	6 (17.1%)
Teignmouth	8	2	39 (79.6%)	10 (20.4%)
Teignmouth	8	3	32 (80.0%)	8 (20.0%)
Teignmouth	8	4	21 (81.5%)	5 (18.5%)

From the results given in Table 1 it is obvious that larvae from all localities, maintained at a temperature of 18 degrees C and 18 hrs photoperiod, produced some pupae which were diapause and some which were non-diapause. In all cases the numbers of non-diapause pupae greatly exceeded the numbers of diapause pupae, but the percentages of non-diapause pupae were highest in the population from S. England (Teignmouth) and from localities in N. England at low altitudes. It is reasonable to infer that at a temperature of 18 degrees C, populations of P. napi would be overwhelmingly bivoltine, although in all the localities we

have sampled at least some genotypes for monovoltinism are present. This temperature is above the mean temperature of the warmest month in any part of the British Isles, so that populations in nature are likely to be somewhat less bivoltine than the experimental data suggests.

The results in Table 2 indicate that larvae maintained at the lower temperature of 12 degrees C behave very differently from those at 18 degrees C, in the extent to which they yield diapause puape. Larvae from three localities (High Force, Bellingham and Dollar) gave no non-diapause pupae under these conditions and those from other localities did not give more than 20% non-diapause pupae. Once again the percentages of non-diapause pupae were highest in the population from S. England (Teignmouth), and the populations which behave in a strictly monovoltine fashion are those from high altitudes in N. England and from Scotland. The experimental data is therefore in agreement with what is observed in nature viz. the occurrence of monovoltine colonies in localities where the summer temperatures are low.

Our findings suggest that populations of P. napi show a physiological cline in relation to the tendency of their larvae to give diapause pupae as one moves from north to south in the British Isles. Northern populations are more prone to give diapause pupae than southern ones and there is a well-defined gradient with extremes at Dollar in Scotland and Teignmouth in S. England. This physiological cline is accompanied by a phenotypic gradient. The female butterflies from Scotland and the extreme north of England have much darker veining to the wings and a proportion of them have a ground colour which is some shade of yellow instead of white. These tendencies, which are more marked in the spring brood, become progressively less evident as one moves from north to south. Warren (1968) has suggested that the northern forms of P. napi should be regarded as forming a distinct subspecies P. napi thomsoni Warren, and Thomson (1970) has described the distribution of the latter. It is obvious from Thomson's account that the phenotypes he describes constitute a cline.

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Fig. 1. Locations of sampled P. napi populations.
 1 - Dollar; 2 - Bellingham; 3 - High Force; 4 - Arnside; 5 - Strensall; 6 - Menston; 7 - Nantwich; 8 - Teignmouth.

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Manuscript Format: Two copies must be submitted (xeroxed or carbon papered), double-spaced, typed, on  $8\frac{1}{2}$  x 11 inch paper with wide margins. Number all pages consecutively and put author's name at top right corner of each page. If your typewriter does not have italic type, underline all words where italics are intended. Footnotes, although discouraged, must be typed on a separate sheet. Do not hyphenate words at the right margin. All measurements must be metric, with the exception of altitudes and distances which should include metric equivalents in parenthesis. Time must be cited on a 24-hour basis, standard time. Abbreviations must follow common usage. Dates should be cited as example: 4. IV. 1979 (day-arabic numberal; month-Roman numeral; year-arabic numeral). Numerals must be used before measurements (5mm) or otherwise up to number ten e.g. (nine butterflies, 12 moths).

Title Page: All papers must have the title, author's name, author's address, and any titular reference and institutional approval reference, all on a separate title page. A family citation must be given in parenthesis (Lepidoptera: Hesperiidae) for referencing.

**Abstracts and Short Papers:** All papers exceeding two typed pages must be accompanied by an abstract of no more than 300 words. An additional summary is not required.

Name Citations and Systematic Works: The first mention of any organism should include the full scientific name with author (not abbreviated) and year of description. New descriptions should conform to the format: male: female, type data, diagnosis, distribution, discussion. There must be conformity to the current International Code of Zoological Nomenclature. We strongly urge deposition of types in major museums, all type depositions must be cited.

**References:** All citations in the text must be alphabetically listed under Literature Cited in the format given in recent issues. Abbrevations must conform to the *World List of Scientific Periodicals*. Do not underline periodicals. If four or less references are cited, please cite in body of text not in Literature Cited.

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# THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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# A Twision the American Genus Anisota

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# A Revision of the American Genus Anisota (Saturniidae)

# J. C. E. Riotte

Department of Entomology, Bernice P. Bishop Museum, Honolulu, Hawaii 96819 and Royal Ontario Museum, Toronto, Canada M5S 2C6

and

Richard S. Peigler

Department of Entomology, Texas A&M University, College Station, Texas 77843

# Introduction

Michener (1952) revised the Saturniidae of the Western Hemisphere at the generic level, but except for occasional mention of species, these were not treated. Recent discovery of new species of the genus Anisota Huebner in Ontario, Texas, South Carolina, and Mexico made it desirable to do research into the morphology of all related species, and as no details have been published about the adults and immature stages of all the North and Central American species of Anisota since Packard (1905) and Bouvier (1931), it seemed advisable to summarize our knowledge in this paper.

# **Higher Classification**

The genus Anisota belongs to the moth family Saturniidae belonging to the superfamily Bombycoidea which also includes Lasiocampidae and Bombycidae (Ferguson, 1971).

The correct subfamily name has been, and continues to be, disputed. Lemaire (1976) indicated that Adelocephalinae, Boisduval 1868, is the correct name. Earlier authors used other names such as Dryocampinae, Ceratocampinae, and Syssphinginae. The name Citheroniinae has had wide usage, even in recent works (Michener, 1952; Ferguson, 1971). The subfamily has frequently been elevated to family rank under the various names throughout much of the literature (i.e., Citheroniidae, Syssphingidae). Whether considered a family or subfamily, the group is clearly a monophyletic assemblage. It is one of the more primitive subfamilies of Saturniidae and is exclusively New World in distribution. Most genera and species are neotropical; Anisota is in fact, the only predominantly nearctic genus of the subfamily, excepting the allied Dryocampa Harris. Michener (1952) and Ferguson (1971) characterized the subfamily morphologically—it is our purpose from here on to deal only with the genus Anisota.

As the lists of synonyms indicate, species of Anisota have often appeared in the literature under several generic names (Adelocephala, Dryocampa, etc.). Fortunately however, the name Anisota has rarely been applied to species which are not true Anisota, an exception being the Brazilian Psigida apollinairei (Dognin) which Grote (1867) redescribed as Anisota walkeri.

Michener (1952) subdivided the genus Anisota into two subgenera: Dryocampa and Anisota, the characters of which may be found in Table 9 of his paper. Ferguson (1971), however, pointed out correctly that the one species belonging to Dryocampa

"seems quite far removed from all the species of Anisota." He therefore elevated Dryocampa to generic rank in which the present authors follow him, especially because of the characters shown in the immature stages, the male genitalia and other morphological characters. In the present paper therefore we only treat the species of Michener's subgenus Anisota. Dryocampa represents a separate migration into North America from the neotropical fauna. The genus is perhaps closest to Anisota (sensu stricto), an idea supported by the work of Pease (1961). We propose that Dryocampa and Anisota are sister-groups, diverged in Central America, and radiated into North America where their respective hostplants (Acer and Quercus) are more available.

# Methods

Genitalic dissections were made of a certain number of male and female specimens of each species from different populations where applicable. Also the heads of male and female specimens were detached from the body, cleaned, measured as to eye-size and head-proportions as well as the form of the rear joint of the head. Also anterior legs were removed and cleaned for examination of the epiphysis. Labial palpi were also removed and cleaned and studied.

Special emphasis was placed on the immature stages. In the larvae, the suranal plate was studied and figured, which is distinct for each of thespecies. The pupae were photographed in a position to show their specifically different cremaster. In two species, scanning electron micrographs (Plate V) were made of the cuticle of larvae (see Byers & Hinks, 1973).

Localities and flight periods for specimens examined are cited under each species account. Full specimen data have been deposited in the library of the Royal Ontario Museum and are accessible for reference. Most of the material collected or received by the authors during the course of this study has been deposited into major museums (notably ROM, AMNH and LACM). The abbreviations used in the text for collections from which material for this study was examined are as follows:

BPBM	Bernice P. Bishop Museum, Honolulu, Hawaii
BMNH	British Museum (Natural History), London, England
CalAcSci	California Academy of Sciences, San Francisco, California

CLU Clemson University, Clemson, South Carolina

CM Carnegie Museum of Natural History, Pittsburgh, Pennsylvania
CNC Canadian National Collection of Insects, Ottawa, Ontario

FIS Forest Insect Survey, Canada

FMNH Field Museum of Natural History, Chicago, Illinois

FSCA Florida State Collection of Arthropods, Gainesville, Florida Heitzman Coll. Collection of J. Richard Heitzman, Independence, Missouri

IBM Instituto de Biologia, Mexico City, Mexico

Kendall Coll. Collection of Roy & C. A. Kendall, San Antonio, Texas LACM Los Angeles County Museum of Natural History, Los Angeles,

California

Lemaire Coll. Collection of Claude Lemaire, France (now in MNHN)
LSU Louisiana State University, Baton Rouge, Louisiana
LM Lyman Entomological Museum, Ste-Anne-de-Bellevue,

Quebec

McM McMaster University, Hamilton, Ontario

MHNM Museo de Historia Natural, Mexico City, Mexico

Cambridge, Massachusetts

MNHN Museum National d'Histoire Naturelle, Paris, France

MSU Michigan State University, Lansing, Michigan

Peigler Coll. Collection of R. S. Peigler, Greenville, South Carolina RIB Entomology Research Institute, Belleville, Ontario (now closed)

ROM Royal Ontario Museum, Toronto, Ontario

Sieker Coll.

Collection of William E. Sieker, Madison, Wisconsin TAMU

Texas A&M University, College Station, Texas

UArk

University of Arkansas, Fayetteville, Arkansas

UCal

University of California, Berkeley, California

UFI

University of Florida, Gainesville, Florida

UG University of Guelph, Ontario

UGa University of Georgia, Athens, Georgia

UII University of Illinois/Illinois Natural History Survey
UM University of Michigan, Ann Arbor, Michigan
UMo University of Missouri, Columbia, Missouri

USNM United States National Museum of Natural History,

Washington, D.C.

USPM University of Minnesota, St. Paul, Minnesota
UWO University of Western Ontario, London, Ontario

YPM Yale University's Peabody Museum of Natural History, New

Haven, Connecticut

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# Generic Diagnosis and Morphology of the Imago ANISOTA HUEBNER

Anisota Huebner, 1820: 192; Michener, 1952: 409. Type species: Bombyx stigma Fabricius, designated by Grote, 1874: 260.

A North and Central American genus of small to medium sized moths of brownish color; always with extremely reduced clypeus in the adult and a white discal spot on the forewing; the male in many cases diurnal; strong sexual dimorphism in some of the species, some sexual dimorphism in all species. Morphological features which all species of the genus have in common as adults are:

- a) male antennae doubly bipectinate; female antennae simple and ciliate
- b) epiphysis in many females absent, not as Michener (1952: 408) and Ferguson (1971: 63) say in all females; Michener's own preparation (AMNH) of an anterior leg of a female of A. virginiensis has an epiphysis; when present much reduced in size
- c) anterior tibia in male and female dorso-apical with two lateral projections, the exterior one usually a long spine, the interior one a much shorter and usually blunt projection; middle and posterior tibiae also with two projections of this kind, but much shorter and in many cases similar in size; middle and posterior tibiae in males and females bear one pair each of tibial end-spurs; a pair of peculiar spines in the females only arises from the apical lobes of the penultimate anterior tarsal segment. Leg morphology is described and figured by Oiticica (1940).
- d) pulvillus, paronychium (lateral lobe) and empodium (generally only one tubercle with one long strong seta) well developed
- e) free anellus in male genitalia present and valves not fused
- f) uncus of male genitalia without protuberance

Michener (1952) says of Anisota: "This subgenus includes most of the species of Anisota. They are brown, with a small white spot at the apex of the discal cell of the forewing. It includes two rather well-marked groups of species distinguished primarily by the size of the eyes. In dissimilis Boisduval and oslari Rothschild the

eyes are reduced in size so that their upper ends do not reach the lower margins of the antennal sockets, and their lower ends do not reach the lower extremity of the frons. In this group, moreover, the frontal protuberance is more reduced and the proboscidial fossa is even shallower than in the other group which contains the remainder of the species. In dissimilis and oslari also the labial palpi are more distinctly two-segmented than in the remaining species of the genus. The species of this subgenus occur in eastern North America, westward to Arizona and south into Mexico."

The basic premise of the foregoing is valid. The species of Anisota can indeed be separated into two groups with the aid of the size of the eyes, or of a certain ratio of the head and the position of the eyes or of the form of the frontal protuberance, or on the basis of the visibility or obscuration of the laterofrontal suture. All of these criteria give rise to identical groupings, and it should be taken into account that it is not so much the size of the eyes as their position and angle to the head which makes the difference, and which makes the eyes appear to be of quite different size. To compare eyes of these moths without exact measurements gives very wrong results; Ferguson (1971: 74) mentions the "very small eyes" of the males of A. senatoria. It is in fact astonishing that exact measurements of the eyes do not show a great difference among the species, except for A. virginiensis which was included by Michener among the "big-eyed" species and actually has the smallest eyes of the entire genus, as correctly pointed out by Ferguson (1971: 74). On the other hand, the eyes of A. dissimilis and A. oslari are in no way "very reduced" as Ferguson (1971: 64) says. Table 1 of the eye measurements will better illustrate these points.

TABLE 1
Eve Measurements (in mm)

Species	a-b in male	a-b in fer	male c-d in male	c-d in female
Group A				
A. consularis	1.30	1.31	0.70	0.65
A. fuscosa	1.70	1.56	1.09	0.96
A. manitobensis	1.43		0.87	
A. senatoria	1.33	1.24	0.70	0.62
A. stigma	1.37	1.44	0.97	0.95
Group B				
A. assimilis	1.23		0.67	
A. discolor	0.98		0.50	
A. dissimilis	1.23		0.70	
A. finlaysoni	1.17	1.17	0.67	0.63
A. oslari	1.14		0.55	
A. peigleri	1.33	1.33	0.60	0.80
A. pellucida	1.04	1.21	0.55	0.72
A. punctata				
A. virginiensis	0.93	1.08	0.50	0.53

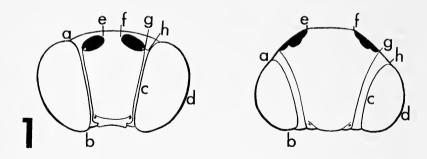


Fig. 1. The two types of heads in *Anisota*, with large and small eyes. See Tables 1 and 2.

The table clearly shows group A with the large eyes and group B with the small eyes. In group A the measurement a-b does not go significantly below 1.33 mm while in group B it does not go over 1.33 mm. In group A the measurement c-d does not go below 0.70 mm while in group B it does not exceed 0.70 mm. Females show slight differences with the males; in group A their measurements tend to be lower than in the males while in group B they tend to be slightly higher. Regrettably there were not enough females available to check every species. In group A the eye measurements separate A. fuscosa from all the other species, especially from the closely related A. stigma. In group B, A. peigleri shows a slight deviation with a-b the highest for the group and c-d just in the middle between the highest and lowest values.

Further examination has shown that in no species the eve reaches the antennal socket at all. To see this clearly the head should be detached, cleaned and measured. If this is done, one finds that the distance between the two antennal sockets (e-f) and the distance between one antennal socket and the upper edge of the eye (g-h), give a ratio which can be very useful in connection with the values of Table 1. See Table 2 and Figure 1. The data in Table 2 corroborate the conclusions from Table 1, namely there are two groups of Anisota species which can be separated by certain eye and head measurements. It is also remarkable that visibility of the later of rontal suture and the size of the frontal protuberance support the groupings established with our measurements. It is interesting to note that A. fuscosa also deviates here by far from the normal values while everything otherwise falls nicely into place. Because of the dissection necessary and the scarcity of some species in collections, it was possible to measure for some species only one specimen, but in the other species where a series of measurements was taken, the variation was very small, indicating that the single ones measured are probably representative of their species, at least in the present context.

The labial palpi show for the entire second group a more distinctly two-segmented condition than in the first group.

Many specimens were dissected as to the genitalia and other anatomical features; also Michener's dissections (AMNH) were used. The form of the aedoeagus of the male genitalia can be furthermore used to divide the second group into two subgroups: A. dissimilis, A. finlaysoni, A. oslari, and A. peigleri have a straight

TABLE 2
Head Morphology
(numbers in mm)

		`	,	
Species	ratio of male	e-f:g-h female	laterofrontal suture	frontal protuberance
Group A				
A. consularis	3.6:1	3.1:1	slightly obscured	very prominent
A. fuscosa	6.7:1	6.0:1	obscured	protruding
A. manitobensis	3.3:1		absolutely obscured	prominent
A. senatoria	3.0:1	3.2:1	slightly obscured	protruding
A. stigma	3.6:1	3.3:1	obscured	protruding
Group B				
A. assimilis	2.0:1		visible	reduced
A. discolor	1.7:1		visible	reduced
A. dissimilis	1.8:1		visible	reduced
A. finlaysoni	1.8:1	2.7:1	visible	reduced
A. oslari	1.9:1		visible	reduced
A. peigleri	1.8:1		visible	slightly protruding
A. pellucida	1.8:1	1.8:1	visible	reduced
A. punctata				
A. virginiensis	1.7:1	1.8:1	visible	reduced

aedoeagus, while A. assimilis, A. discolor, A. pellucida, and A. virginiensis have the aedoeagus curved. In the first group the aedoeagus is straight in all species. It is noteworthy that the female genitalia, which were not studied by Ferguson (1971), also support the above grouping: only the A. assimilis subgroup has a prominent antrum and this is of an unusual form when seen in lateral view (Figure 8), and in all species of the second group the ductus bursae makes an abrupt, almost rectangular turn where the bursa copulatrix is attached. In all species of the first group the ductus bursae is straight.

In some species of the genus a special sexual dimorphism occurs as a parallel development in both groups. This character has been used by previous authors for the purpose of subdivision of the genus into species groups. However, this seems to be artificial and untenable and it should be recognized that other morphological features form a better basis for a natural grouping of similar species within Anisota. For a correct interpretation of the somehow striking sexual dimorphism see Ferguson (1971: 63). Some diurnal males have evolved very transparent forewings (A. pellucida, A. discolor, A. virginiensis) or tend toward that (A. senatoria, A. peigleri); other diurnal males (A. oslari) show no such trend but nonetheless probably also resemble orange wasps (Vespidae) in flight.

It does not seem justifiable to correlate reduction in eye size with a trend to diurnal activity (see Ferguson, 1971: 63). Our Table 1 shows clearly that there are small eyes among species with sexual dimorphism as well as among those without,

and the same is true for large eyes. It is also important to consider the statement of Mazokhin-Porshnyakov (1969: 2): "As a rule, the mobile and fast flying species, both diurnal and nocturnal, have large complex eyes; male insects often have bigger eyes than females."

# Morphology of the Immature Stages

Egg. This is, according to Packard (1905): "elliptical, flattened, each end alike, a little longer than broad, shell very thin, parchment like, the surface with obscurely marked microscopic irregular hexagonal areas. The eggs are laid in large patches on leaves". We add: patches on older leaves with preference at apices of leaves on the lower perimeter of the tree.

Larva. Larvae, according to Packard (1905) with "body cylindrical, slightly flattened at the end; armature consisting of two recurved slender smooth mesothoracic horns [except for A. finlaysoni]; prothoracic spines reduced to low tubercles; all other dorsal and lateral spines of the body small, conical, acute; the two dorsal spines of the eighth abdominal segment, remote, not fused into a caudal horn. Suranal plate rugose or granulated, with from three to four lateral and two terminal stout conical spines. Body with conspicuous longitudinal bands or stripes." The latter, however, is not always the case. The headcapsules and suranal plates are specific and figured as far as possible. Here it should be noted that in Peterson (1959: Fig. L 12) the captions of H and C should be interchanged, i.e., H should read "A. senatoria" and C should read "A. stigma".

Pupa. About the pupa Mosher (1916) (see also Mosher, 1914) says: "Without prominent scattered spines on the thoracic segments, the longest never four times the length of those covering the segments; antennae with the central axis never bearing pominent spines, the spines never curving posteriorly; maxillae always one-fourth the length of wings". We provide figures of the species-specific cremasters of species for which these were available. These structures have been shown to be taxonomically useful (Giehsler, 1965).

# Intrageneric Classification and Phylogeny

Different groupings may be derived for the 15 species of *Anisota*, depending on characters used. Eye size and head morphology discussed earlier give one such arrangement, whereas genitalia give another. However, we prefer the following groupings based on habitus of larvae and adult moths as well as geographical distributions:

A. senatoria group	
A. senatoria	
A. finlaysoni	
A. peigleri	
Mexican group	
A. dissimilis	
A. punctata	
A. assimilis	
A. oslari	

Certain features of the zoogeography are clear while others are difficult to ascertain. The genus evidently originated in Mexico or southward, possibly as specialized feeders on oaks. The distribution and numbers of species in North America was likely greatly influenced by glaciation and other climatic changes during the Pleistocene.

Larger size of the adults, very spiny larvae, south Mexican distribution, and nocturnalism are judged to be plesiomorphic characters (based on outgroup comparison) in such species as A. dissimilis. Both A. dissimilis and A. punctata show affinities with the A. stigma group; A. assimilis shows a relationship to the A. pellucida group through the genitalia. All of the species appear to be still very closely interrelated and the above four groupings merely indicate still closer affinities. It is likely that there remain undiscovered species in Mexico or southward. Lepidopterists have traditionally collected most heavily in lowland rainforests where the fauna seems richer, and Anisota are more likely encountered in oak-pine biotope in the mountains. If new species are described from the United States or Canada in the future, these will likely be ones which are presently "hiding" under names of widespread and variable species such as A. stigma, A. virginiensis, and A. senatoria.

The phenomenon of allopatry is quite evident with the most closely related species. When species are so alike in their ecological requirements (i.e., fill the same niche), then they are mutually exclusive or ecologically antagonistic, possibly due to competition or more likely the absence of isolation mechanisms to prevent hybridization (see Mayr, 1969, p. 193-197; Stebbins, 1969). Such allopatry or parapatry have led workers to consider that some of these species are merely subspecies. Our observations indicate that all 15 taxa which we herein recognize are full, discrete species. We have noted consistent differences in genitalia of both sexes, adult phenotype and leg morphology, larval color and morphology, pupal morphology, egg size and embryo development; and in the A. pellucida group we have observed sterility and inviability in F2 and backcrosses of artificial hybrids. Furthermore we find no indications of blend zones or clines, despite the immense amount of material examined. Van Valen (1976) offers an interesting discussion on these matters.

To elaborate on this important concept of allopatry let us view some specifics. Any given locality tends to have only one representative from a given group: in New Jersey one will collect A. stigma, A. senatoria, and A. virginiensis; in upper South Carolina one collects A. stigma, A. peigleri, and A. pellucida; in East Texas we find A. fuscosa, A. senatoria, and A. discolor.

Although we do not promote usage of common (vernacular) names for these insects, a few remarks may be appropriate here. According to one list (Benoit, 1975) the English and French common names for four species are: A. finlaysoni, shorthorned oakworm, anisota de Finlayson; A. senatoria, orange-striped oakworm, anisota a lignes orangees; A. stigma, spiny oakworm, anisote stigma; A. virginiensis, pink-striped oakworm, anisote rose du chene. Holland (1903) refers to A. virginiensis as "the Virginian Anisota" and A. stigma as "the Stigma Moth". Names such as spiny, pink-striped, and orange-striped oakworms have become less appropriate with the discoveries of more species in recent years, since each name might apply to an entire group of species.

The species of Anisota are arranged alphabetically in the text for convenient reference in their groups: Mexican group - pellucida group - senatoria group - stigma group.

# **Key to Adults**

IX	ey to Adults
1.	antennae doubly bipectinate (males)
2.	forewings with hyaline area around discal cell. 3 forewings without hyaline area around discal cell. 4
3.	medium reddish brown; outer margin of both wings perceptibly convex; anal angle of hindwings all rounded; aedoeagus of male genitalia rounded
	deep reddish brown; outer margin of both wings straight or nearly so; anal angle of hindwings not rounded; aedoeagus of male genitalia more slender and oblong.
	A. pellucida deep yellowish brown or soft brown; when fresh with a slight grayish hue; outer margin of both wings convex; anal angle of hindwings strongly rounded; aedoeagus of male genitalia rounded, more narrow than in A. virginiensis but a little wider than in A. pellucida, proximal end straight
	light brown or soft brown; sprinkling with dark scales strong; outer margin of foreing perceptibly convex, of hindwing straight; anal angle of hindwing rounded; only known from Florida and Georgia
4.	straight
	western Texas
	dark scales; outer margin of both wings entirely rounded, especially apex of forewing
<ul><li>5.</li><li>6.</li></ul>	connection (ductus bursae) between ostium bursae and bursa copulatrix straight

	between M3 and apex; postmedian band usually quite visible; ductus bursae obviously slender
	scales; outer margin of both wings well rounded
	both wings well rounded
	almost uniformly medium orange colored with a slight pinkish tinge on the
7	hindwing; Mexico only
7.	terminal areas; ductus bursae only slightly bent to the left; Manitoba to Wisconsin
	deep orangish yellow forewing; hindwing duller, somewhat suffused with blackish-brown; venation on both wings of same color; abdomen blackish-brown, joints of segments outlined in ochreous brown; ductus bursae sigmoidal;
	Mexico only
	nounced; abdomen tawny olive-ochreous; head and thorax same; postmedian lines very strongly developed; strongly sprinkled with dark scales. A. punctata
	light brown with a light ochreous tinge; hindwing slightly darker; ductus bursae
	sharply bent to the left; Mexico, Arizona to western Texas A. oslari
	unicolorous deep orange yellow to medium yellow brown; strongly sprinkled with dark scales; outer margin of wings as in male; ductus bursae twisted twice;
	eyes strikingly large
	soft yellow; outer margin only slightly rounded between Cu 1b and apex;
	postmedian lines on both wings straight; but weak; purplish suffusion in
	terminal area very reduced; ductus bursae twisted upwards A. finlaysoni deep orange yellow; mostly strongly sprinkled with dark scales, marginal area of
	forewing purplish; outer margin almost straight; large (25-30 mm); ductus bursae twisted twice
	considerable contrast between gray purplish pink terminal area and remainder
	of wing brownish orange or wine colored; rarely with dark scales; ductus bursae sharply bent to the left
	wings opaque and occasionally with dark scales and strongly colored medium
	reddish brown; ductus bursae bent to the left directly cephalad of antrum
	A. pellucida
	monotonous light brown to dark orange yellow; sometimes with grayish over-
	tones; often sprinkled with dark scales; bursa copulatrix very slightly bent off of ductus bursae
	size large; deep orange yellow; terminal area of forewing slate; ductus bursae twisted twice; Central America
Κe	ey to Mature Larvae
1.	unicolorous
2.	in two colors (light gray olive and deep pink) evenly and widely striped; thoracic
	horns 6 mm long; head deep yellow
	head deep greenish yellow

	in two colors (dark olive and very deep red); not quite evenly striped; thoracic
	horns 8 mm long; head medium olive
	first three abdominal segments yellow, following ones reddish brown; thoracic
	horns long and blunt on tips; black spots between abdominal segments; head
	yellow
3.	unicolorous black
υ.	
,	other color
4.	color soft red with broken yellow stripes; body very strongly granulated;
	thoracic horns 5.5 mm long; head deep orange
	color various shades of brown, densely covered with pinkish white granulations
	of uneven size; laterally paler stripes only faint; thoracic horns 7 mm long; head
	brownish orange
	color light brown, on each segment a very wide black saddle; on saddle pinkish
	white granulations of uneven size; thoracic horns 5 mm long; head deep orange
	yellow
	color medium orange to light brown; body covered with many white spots and
	ecrescences; dorsal, lateral, supraventral brownish stripes; gray dorsal band;
	thoracic horns clubbed, 5 mm long; head brownish orange A. fuscosa
	color medium orange with lighter brown stripes; thoracic horns 6 mm long; head
	pale tan
	color various shades of tan, with numerous longitudinal thin black stripes;
	thoracic horns ca. 6 mm long; head brownish orange
5.	with very orange yellow continuous stripes; thoracic horns 4 mm long; head
	blackish red brown
	with sometimes faint, interrupted very orange yellow stripes; subspiracular
	"ornaments" much reduced; thoracic horns 6.5 mm long; very spiny; head
	black
	with brilliant orange yellow continuous stripes, no thoracic horns except a pair
	of short scoli 1 mm long; head black
Mo	ste: The names of colors used in the foregoing keys follow those given in the
TAC	te. The hames of colors used in the foregoing keys follow those given in the

Note: The names of colors used in the foregoing keys follow those given in the Inter-Society Color Council—National Bureau of Standards, Circular 553.

# Ecology, Collecting in the Field, and Rearing in Captivity

Rearing and collecting the various species of Anisota is an integral part of studying them. These activities can be very profitable because it is generally easy to collect larvae on trees and adults at lights. The larvae are rather easy to rear in captivity. The senior author has studied the species in southeastern Ontario; the junior author has collected from North Carolina to Florida across to Texas and in Mexico and Ontario.

Searching for ova is generally unproductive unless one is in an area where high populations exist of one or more of the species. It is then best to search on the undersides of oak leaves not too high from the ground. The heavy females do not oviposit in the tops of trees unless the tree is only a couple meters high. Isolated trees, or those along a forest-field interface are good places to search. Trees near lighted areas (such as rest areas on major highways) which attracted female moths are more likely to have ova and larvae. Larvae begin feeding on the leaf which bore the ova so it is advisable to look for chewed leaves on ends of branches. When larvae only a few days old are found in this manner, the egg patch is also present nearby. The remaining ova may contain ovarian parasites.

Larvae of Anisota are gregarious all through life, especially in the early instars. Young larvae spin invisible silk mats to aid aggregating behavior. Mature larvae will spread out over an entire small tree but on large trees they all are generally on one or few branches, still relatively near each other. When a collector begins to detach larvae which he has found, the adjacent ones detect the danger and drop to the ground; even larvae in molting position will drop. Larvae are very easy to remove from branches, never hanging on tightly as in many Saturniidae. Molting larvae detached from their silk pads almost always molt successfully, even in the bottom of a glass jar. Larvae sit on twigs in clusters in the position of sphingid larvae, with the anterior end raised. Brodie (1929) described and figured this behavior. Larvae also will sometimes sway rapidly from side to side in unision when disturbed. This behavior is not understood. To collect the largest larvae among a colony is to collect mostly females. It is tempting to take large ones because one figures that less rearing work will remain to be done. Male larvae, being smaller, mature sooner and leave the tree several days earlier than their female siblings.

Since the defoliation is usually quite noticeable, it can be productive to look for colonies while driving along a road, but sometimes, in the Southeast at least, the defoliators turn out to be colonies of *Datana* spp. (Notodontidae). First-instar larvae of *Datana* skeletonize leaves, unlike *Anisota*. Other times the larvae of *Anisota* have left the tree already to pupate. If the defoliated branch has begun to recover by producing new leaves, one can assume the larvae left weeks earlier. If no new leaves have yet formed, it is often possible to find a few straggling larvae, or at least some exuviae, to determine which species had been present. We have observed that the same individual trees, indeed certain lower branches, are defoliated year after year by the same species of *Anisota*.

Larvae of certain species of the genus are not well camouflaged. The coloration of those species such as A. senatoria (black with orange stripes) is apparently aposematic. Immunity to avian predation may be due to the tough spiny texture of the caterpillars and/or to possible toxic substances, such as tannins derived from oak leaves.

It is incorrect to assume that Anisota are found on any oak. All oaks are accepted freely in captivity; larvae will feed on a mixed diet of several oak species with no hesitation. The tough evergreen oaks such as live oak (Quercus virginiana Miller) are eaten freely as well as the species of Castanea, the chestnuts and chinkapins. Possibly the nearly extinct American chestnut (Castanea dentata (Marshall) Borkh.) was a major host in the past. Species of Quercus with tough, pubescent, or evergreen leaves are generally the least preferred in nature. In an area with several species of oaks, one will find some species attacked growing among others unattacked. Ovipositing females are apparently very discriminating. In the Southeast (North Carolina to Florida to East Texas) the two favorites are undoubtedly water oak (Q. nigra L.) and southern red oak (Q. falcata Michaux). The former is commonly planted in yards and parks and may be heavily defoliated. Other favorites are Q. marilandica Muenchh., Q. velutina Lam., Q. phellos L., Q. palustris Muenchh, and similar species. Q. alba L., Q. stellata Wang., and Q. virginiana are not frequently attacked. However, in extreme southern Florida it is probable that Q. virginiana is a usual host because other oaks are not available. Likewise in Texas, west of the forested areas of the eastern part of the state, the Anisota are obliged to live on Q. stellata, the most prevalent oak. In France, Dr. Claude Lemaire has reared

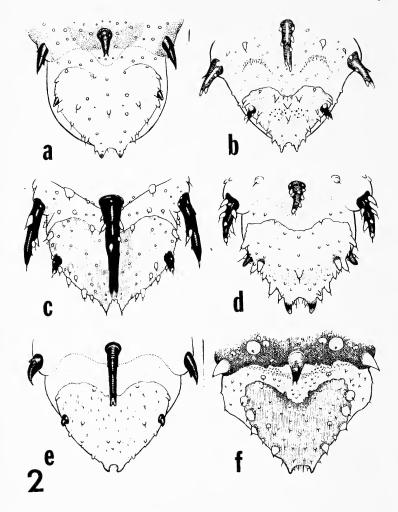


Fig. 2. Suranal plates of mature larvae: a. A. stigma, b. A. fuscosa, c. A. consularis, d. A. manitobensis, e. A. oslari, f. A. assimilis.

species of Anisota from the Atlantic states with a little difficulty on Q. pubescens Willd., a species similar to Q. stellata, but found that larvae of A. discolor from Texas did especially well on that host. Tough and/or pubescent leaves are more offensive to very young larvae. Reports of larvae eating hazel (Corylus) (Packard, 1905; McGugan et al., 1958) we believe to be correct.

It is also apparent that the hot, dry, sandy, scrub-oak areas, so suitable for *Hemileuca* (Saturniidae), are not suitable biotope for *Anisota*. These areas include turkey oak (*Q. laevis* Walter) and myrtle oak (*Q. myrtifolia* Willd.) growth from central South Carolina down through Florida and the limestone hills with *Q.* 

fusiformis Small in central Texas. Anisota are sometimes collected in such areas, but the populations are very low, if at all present.

When larvae have finished feeding they drop to the ground and begin to wander for a day or so in search of a place to enter the ground to pupate. Collecting of larvae crawling on the ground is desirable because no further feeding is required by such larvae, but some parasitism should be expected. It is virtually impossible to locate pupae in the soil so we recommend the collector not waste his time in such an endeavor. Nematodes may attack pupae in the soil but we have no records for this. Pupal mortality may also be caused by occasional flooding or droughts.

The best method for collecting adult moths is to attract them with ultraviolet or mercury vapor lamps (such as street lights). One can hang an ultraviolet light or lantern in front of a sheet. White light sources near a brick wall or similar surface (the lighter colored the substrate is, the better) are very suitable places to find adults because a suitable resting place is available to the moths after arriving at the light. Adults which have been at rest are very lethargic and thus easily captured; they will drop into a box or killing jar if gently pushed. Females of A. peigleri arrive at light just at dark whereas males of A. stigma may not arrive until 2:00 AM (EST). Most adults are available under lights before midnight except, of course, those species with diurnal males which are rarely taken at lights. The earlier in the day that the male flies, the fewer at light: we know of only one male A. pellucida taken at light. The rare cases where diurnal males are found at light may involve individuals which were brought there by the larger females, the female flying to the light before copulation had terminated. This is only a theory but often pairs are found near each other under light sources.

Males can be attracted to females which will emit pheromone in captivity. We believe that the pheromone is the same, or about the same, for all the species (see our remarks under "Artificial Hybridization"). Therefore a female of any species may attract males of any other species, provided that she emits pheromone at the right time of day or night, during the correct season, and in the right location. Hybridization of the species in nature is prevented by allopatry, different flight times of day and night, and/or different flight times through the year. Adjusting of the photoperiod with artificial light or darkness allows one to induce a female to emit pheromone at any desired time. Assembling males are rapid fliers, and a net is usually necessary to capture them.

Several handbooks are available to provide information on rearing caterpillars. Consequently, we only wish to give here a few remarks peculiar to, or important in, the rearing of Anisota. Larvae are easy to rear but tend to stunt easily when reared in containers on cut food and the result is undersized adult moths. Best rearing is done in large cloth bags on limbs of oaks because such growing food provides more nutrition than cut food. Also ventilation and sunlight should reduce incidence of disease in a brood. However, once larvae stop feeding they cannot be left in the bags to pupate as with cocoon-spinning species. There is no evidence that a diet of several oak species produces larger or healthier larvae. Humidity may be advantageous.

Although most lepidopterists prefer to let larvae which pupate subterraineously burrow into a container of soil, this is not at all necessary. Contracted larvae pupate quite successfully in any container, with no soil, or they can be placed on a layer of moist sand or peatmoss. Summer pupae destined to produce adults in less than one month generally do very well if simply kept from dessication. However, with

diapausing (over-wintering) pupae one should expect some mortality. One method which the junior author uses is to keep pupae on a layer of moist-to-wet sand in a plastic shoebox in the refrigerator (ca. 4-5°C) all winter. A too tight lid results in molding; too open causes dessication; both will be fatal to the pupae. Misting of pupae with water triggers emergences.

The diapause is apparently broken by longer day length rather than higher temperatures. Anisota-pupae kept at room temperature (ca. 25°C) all winter still produce adults at the normal emergence time in many cases. Pupae kept under laboratory conditions sometimes yield adults in autumn or spring, while summer is the normal flight time for the particular species. It is possible that the diapause is attuned to specific needs in the phenology such as host plant requirements. Even in the milder climates, larvae of Anisota strongly tend to be late season feeders. In such areas there is ample time for another generation but this does not occur. Probably larvae of the genus require mature oak leaves. Other lepidopterous larvae require spring foilage of oak. The levels of proteins, carbohydrates, and tannins in oak leaves change through the seasons. The excellent study by Feeny (1970) will provide the reader with more information.

When adults emerge the rearer may wish to obtain matings or cross-matings. Males can be kept refrigerated for several days until a female is available. The container in the refrigerator should have a damp cloth. Such chilled males will become active within a few minutes after being taken from refrigeration, and will mate quickly with a female which is emitting pheromone. Females which are chilled in this manner however, usually fail to emit pheromone afterwards. Hand-pairing has not been successful with the small adults.

A problem is encountered if one tries to hold adult moths for long periods at room temperature. Emergences from pupae are in morning or mid-afternoon, depending on species and geographic location, and the moths of both sexes commence to flutter at dusk. If specimens are needed for a collection but one is also hoping to obtain pairings, we recommend that they be kept beside a lamp all night while alive. Another practice used to prevent wing damage can be tried with females after they have mated. This is to put them into envelopes with wings folded back while ovipositing. While this method works well for large saturniids, the females of Anisota seem to prefer to flutter some and more eggs will probably be obtained from a female kept in an open container. The presence of oak foliage does not appear to increase oviposition. It is likely that almost all females of Saturniidae taken at lights have mated and will thus lay fertile ova. This usually appears to be true for females of Anisota, but not always. Some individuals oviposit freely; others do not, even if mated.

The rearer choosing to send out ova to enable others to rear larvae should keep in mind the remarks of Hitchcock (1961b), i.e., first-instar larvae have higher mortality in smaller groups. The very young larvae apparently work as a team in cutting the oak foliage. Therefore, it is best to supply at least 30 ova to another rearer.

Population levels or densities may be estimated in an area by abundance of larval colonies or by numbers of adults taken at lights. The two do not always appear to "agree" however. For example, in northwestern South Carolina A. peigleri is consistently abundant as a larva but adults are taken only occasionally at lights. In the same area larvae of A. stigma are difficult to find but adults are abundant at lights. The apparent discrepancy is explained by the fact that females are taken at

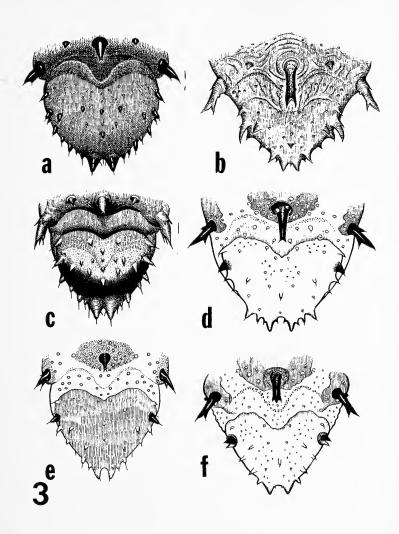


Fig. 3. Suranal plates of mature larvae: a. A. senatoria, b. A. peigleri, c. A. finlaysoni, d. A. pellucida, e. A. virginiensis, f. A. discolor.

light less often than males, and males of A. peigleri are diurnal. Therefore, many males of A. stigma are collected at lights, some females of both species, and rarely any males of A. peigleri.

Females of some species such as A. senatoria and A. peigleri deposit high numbers of ova in one place, and this contributes to the ability of such species to become pests by extensive defoliation. Larval colonies of other species such as A. stigma and A. pellucida usually contain less than 25 larvae. If fecundity of all species is roughly

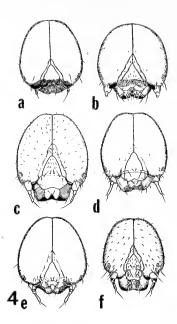


Fig. 4. Head capsules of mature larvae: a. A. stigma, b. A. fuscosa, c. A. consularis, d. A. manitobensis, e. A. oslari, f. A. assimilis.

equal, we can assume females of the latter species oviposit in more sites, but fewer eggs per site.

In Florida and coastal Georgia, populations of A. pellucida are consistently high. Anisota peigleri has maintained a very high population in upper South Carolina for at least 12 years; in East Texas the same appears to hold for A. senatoria. The sporadic outbreaks of A. senatoria in New England are a very different phenomenon. In this case we would use the ecologists' term "fugitive species" for A. senatoria. Fortunately, Anisota is a group which is not especially harmed by human interference such as habitat destruction, since the various species live well in yards and parks where oaks are planted, as well as in the countryside. Conservation of populations of Anisota may become necessary however. Hessel (1976) mentions A. finlaysoni as suffering from habitat destruction. Indeed we have noted an absence of records for this species between Toronto and the type locality and suspect that agricultural practices have destroyed most oaks in that area. Many forest entomologists consider A. senatoria to be a pest such as Ignoffo et al. (1973) in Missouri and Hitchcock (1958, 1961a) in Connecticut. Large scale sprayings with chemicals or pathogens should be used only where absolutely necessary. The aerial application of spores of Bacillus thuringiensis Berliner is hailed as harmless to the environment by entomologists attempting to control populations of the gypsy moth (Lymantria dispar (L.), Lymantriidae). That claim is absurd since the pathogen kills many nontarget species of Lepidoptera.

Collecting of material throughout the range of the genus is needed to augment what is known about the group. Amateur lepidopterists can make significant

contributions by preserving adults and associated larvae from localities where they collect. Data are especially needed for circadian flight times of even the common and widespread species. Some of the aforementioned field observations may only be applicable to the southern states, creating the need for information on some northern populations for comparison. The lack of material and information for the Mexican species is particularly obvious. The mechanisms of diapause in Anisota are poorly understood. It is hoped that our information in this section will stimulate additional research by others.

# Parasitism

During the larval stages, the species of Anisota are much more vulnerable to attack by parasites than predators. The known parasites all belong to the orders Diptera and Hymenoptera. Records for parasitism in species in the northeastern states (A. stigma, A. senatoria, A. virginiensis) can be found in Schaffner & Griswold (1934) and Muesebeck et al. (1951). For tachinid parasitism one can do no better than to consult Arnaud (1978). The junior author has reared parasites from Anisota in the southern states and a list of these plus notes on their habits follows. Our records from Maryland were provided by Robert T. Mitchell.

# Diptera

Tachinidae: Goniinae

Lespesia datanarum (Townsend) (= Achaetoneura anisotae Webber). In A. pellucida from Martin, Florida; Ludowici and Statesboro, Georgia; in A. peigleri

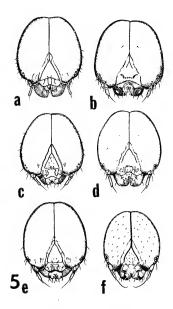


Fig. 5. Head capsules of mature larvae: a. A. senatoria, b. A. peigleri, c. A. finlaysoni, d. A. pellucida, e. A. virginiensis, f. A. discolor.

from Clemson, Greenville, and Westminster, South Carolina. The ovipositing flies deposit their eggs on a larva and the maggots feed inside the host, emerging to pupate in soil after the host has pupated. Parasite puparia will generally diapause at the times that the host species does. Usually there is one to three parasites per host.

Eumasicera sternalis (Coquillett). In A. consularis from Statesboro, Georgia and in A. virginiensis from Pine Grove, Pennsylvania. These flies have a life-cycle much like L. datanarum but the adults are lighter gray and smaller.

Belvosia bifasciata (Fabricius). In A. senatoria and A. discolor from Walker Co., Texas. (What is apparently this species has been reared from A. assimilis by R. O. Kendall from Chihuahua.) These large flies have yellow-tipped abdomens and can be seen flying around defoliated oak trees in the autumn searching for hosts. The phenology is similar to L. datanarum but these are solitary (gregarious in larger hosts such as Eacles) parasites and the maggot does not leave the host pupa to pupate.

An undetermined species of Tachinidae attacks *A. finlaysoni* in St. Williams, Ontario (size of *Lespesia*, puparium obtained only; specimen in Royal Ontario Museum).

# Hymenoptera

# Trigonalidae

Poecilogonalos costalis (Cresson). In A. discolor and A. senatoria from Walker Co., Texas. This insect superficially resembles a yellowjacket (Vespula maculifrons (Buysson)). It occurs solitarily and is probably a hyperparasite on tachinid parasites in Anisota. Trigonalids represent a small and poorly known family.

#### Ichneumonidae

Hyposoter fugitivus (Say). In A. peigleri from Greenville and Clemson, South Carolina; in A. pellucida from Anderson Co., S. C.; Baton Rouge, Louisiana and Saint Francis Co., Arkansas; in A. discolor from Giddings, Texas; in A. senatoria from Walker Co., Texas; in A. consularis from Statesboro, Georgia; in A. fuscosa from Brazos and Walker counties, Texas. In A. finlaysoni from Shannonville, Ontario (leg. L. R. Finlayson, in alcohol in Royal Ontario Museum). The species is reported by Muesebeck et al. (1951) to attack A. stigma, A. virginiensis, A. senatoria and numerous other hosts in Saturniidae and other lepidopterous families. In Anisota very young larvae are attacked. In the second or third instar the host dies and its dried skin is fastened to a leaf or stem by the parasite larva within which it spins its cocoon within the host (figured by Felt, 1930). In Baton Rouge we found the incidence of parasitism to be extremely high and encountered no hyperparasitism.

The following species of Ichneumonidae are hyperparasites of H. fugitivus: Gelis tenellus (Say) in A. peigleri from Hendersonville, North Carolina; Lymeon orbus (Say) in A. fuscosa from Walker Co., Texas; Isdromas lycaenae (Howard) in A. peigleri from Hendersonville, N.C. The last species closely resembles its host, H. fugitivus, but is smaller. The material from North Carolina was given us by David Montross, entomologist at Clemson University.

# Braconidae

Apanteles anisotae Muesebeck. In A. discolor, A. fuscosa, and A. senatoria from Walker Co., Texas and A. fuscosa from Brazos Co., Texas. These small black wasps affect larvae in any instar. When mature, the parasitic larvae emerge and spin light yellow cocoons on the surface of the host. Larger hosts support more parasites but the number rarely exceeds ten.

#### Chalcidae

Ceratosmicra meteori Burks. This yellow wasp is a solitary hyperparasite of H. fugitivus in A. fuscosa from Brazos and Walker counties, Texas and in A. peigleri from Clemson and Seneca, South Carolina and Hendersonville, North Carolina. R. T. Mitchell has taken both this species and Spilochalcis albifrons (Walsh) as hyperparasites of H. fugitivus in A. senatoria at Patuxent Wildlife Research Center at Laurel, Maryland.

# Eupelmidae

Anastatus reduvii (Howard) (possibly a synonym of A. semiflavidus Gahan). In A. pellucida and A. consularis from White Springs, Florida; in A. consularis from Statesboro, Georgia; and in A. fuscosa, A. discolor, and A. senatoria from Walker Co., Texas. These tiny wasps are ovarian parasites; usually less than half the eggs of an egg mass is attacked. The parasites emerge from the host eggs several days after the larvae of Anisota eclose from the adjacent unaffected ova. This is because the parasites must develop through a larval and pupal stage within the host egg. There is only one parasite per host egg. Beal (1952) reported a species of Anastatus in A. senatoria [A. peigleri?] in North Carolina. The wasps also attack ova (the overwintering stage) of saturniids in the genus Hemileuca (Watts & Everett, 1976). Eulophidae

Horismenus floridanus (Ashmead). This is a solitary hyperparasite in Apanteles anisotae from Walker Co., Texas. It emerges from the side of the cocoon, whereas adults of Apanteles exit from the end of their cocoon. The females of H. floridanus oviposit in the larva of Anisota, this being clear because the hyperparasites emerged from Apanteles which had emerged from their host and pupated in the lab

(unexposed).

Tetrastichus sp. or spp. In Anisota from Walker Co., Texas and in A. peigleri from Greenville, South Carolina. The minute wasps are egg parasites much like A. reduvii. They can be stramineous or black but this color difference may be sexual rather than taxonomic. Hitchcock (1961b) records these parasites from A. senatoria in Connecticut.

# Perilampidae

Perilampus carolinensis Smulyan. In A. senatoria from Laurel, Maryland (R. T. Mitchell). This larval parasite is metallic blue and about 4 mm long. Apparently is a solitary endoparasite killing half-grown larvae.

Most parasites attacking Anisota are not host-specific to the genus. Many have geographical distributions wider than the individual species of Anisota, thus attacking the different host species in different parts of their (the parasites') range. Some species of Cratichneumon (Ichneumonidae) are also recorded as parasites in Anisota (Hitchcock, 1961c; Heinrich, 1977). Voucher specimens for most of our above records are in the USNM and other museums.

## John Abbot

An early pioneer naturalist and artist of Georgia was John Abbot (1751-1840?) who sent countless specimens and paintings of these to European museums and collectors. Excellent biographical treatments are given by Coulbourn (1973) and Harris (1972); the latter also provides a bibliography on sources about Abbot's life.

Before leaving England at the age of 22, Abbot had made the acquaintance of the

entomologist Mr. Dru Drury. After settling in Georgia in 1776 Abbot sent many lifesized colored illustrations of insects to such persons as Dr. J. A. Boisduval of Paris and Dr. James Edward Smith of England. Two species of *Anisota* were figured as new in the book by Smith: *The Rarer Lepidopterous Insects of Georgia* published in 1797. Smith used some of Abbot's drawings in his book with appropriate credit to the artist, and this is why the authorship of many Lepidoptera (including *A. senatoria* and *A. pellucida*) is sometimes seen in the literature as "Abbot & Smith".

Although Abbot lived in Georgia in Burke County (a part of which later became Screven County) and also in Bulloch County, we cannot do more than assume type localities for taxa described and figured in Smith's book. There is even the possibility that some specimens Abbot used as models for his paintings originated from areas outside of Georgia.

Other taxonomic problems created by this book include the fact that some plates contain larvae of one species mixed with adults of related species (Riotte, 1972: 11 and Ferguson, 1978: 82), and the fact that the drawings, however elegant, must be interpreted as diagramatic at best and should not be given the favor that systematists would afford color photographs. Colors on the plates differ from copy to copy which was a main reason for creation of the synonymy of A. virginiensis sinulis, the material not agreeing with some figures of A. pellucida. Also the copy of Smith's book in the Carnegie Museum library has very light-colored figures of "Phalaena stigma" so that we were at first certain they represented A. consularis (larva, male, and female). Later we decided they probably indeed represent A. stigma upon viewing the differently colored plates in the copy at the CNC in Ottawa. Comments on the correct interpretation of Abbot's plate of "Phalaena senatoria" are given under our text of that species. We have attempted to overcome these taxonomic difficulties by consulting the original plates for the book in the BMNH and designation of neotypes of the concerned taxa.

# Treatment of the Species

MEXICAN GROUP

## Anisota assimilis (Druce)

Dryocampa assimilis Druce, 1886: 170, pl. 15, fig. 5.

Anisota assimilis; Bouvier, 1931: 22; Schuessler, 1936: 212; Draudt, 1930: 814; Hoffman, 1942: 245; Ferguson, 1971: 64; Lemaire, 1976: 47.

Anisota leucostygma (not Boisduval, 1872); Draudt, 1930: pl. 142f; Bouvier, 1931: 18 (partim); Hoffman, 1942: 245. [Error in determination.]

#### ADULT

Male (pl. IV, fig. 11): Head, thorax, legs, abdomen reddish brown; fore- and hindwings uniformly reddish brown, more brown on forewing, hindwing more reddish; postmedian line only very slightly marked on both wings on upperside, a little more pronounced on underside; white discal spot small. Underside of wings colored as upperside but lighter. Outer margin slightly rounded in forewing and more so in hindwing. Length of forewing 21-23 mm (4 specimens measured).

Female (pl. IV, fig. 12): Described here for the first time. Head, thorax, abdomen, legs, fore- and hindwings on upper and underside all almost uniformly lighter or darker fawn colored, with a pinkish tinge on the hindwings; less intensely colored outside postmedian line; no dark scales on wings; postmedian line barely

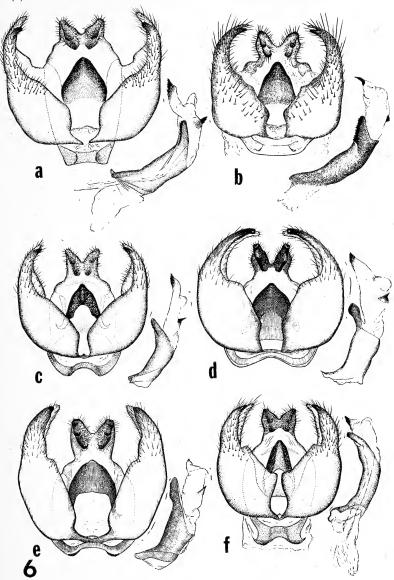


Fig. 6. Male genitalia, with aedoeagus removed and alongside: a. A. stigma, b. A. fuscosa, c. A. consularis, d. A. manitobensis, e. A. oslari, f. A. assimilis.

perceptible; a little more conspicuous on underside; white discal spot larger than in male. Outer margins as in male. Length of forewing 30-35 mm (3 specimens measured).

Head: Laterofrontal suture visible. Frontal protuberance transverse, not prominent. Male antenna with 18 rami. Posterior aspect of head not investigated because of rarity of specimens.

Legs: Male epiphysis slender, a little longer than half the length of the tibia, densely covered with very short hairs, a few long ones laterally and at apex; empodium as usual, with one moderately long seta; epiphysis in female not found.

### **GENITALIA**

Male (fig. 6f): Uncus M-shaped, apices heavily chitinized and broadly triangular; gnathos narrowly triangular; valves uneven interiorly, more straight than rounded, ventral part of bifurcation pointed and strongly chitinized; dorsal part of equal length but much wider and blunter than the ventral pointed end; free anellus heart-shaped with broadly rounded apices; saccus very much elongated cephalad into two spoon-shaped structures which are joined together by a bridge. Aedoeagus larger than in other groups, curved, but not as much as in A. virginiensis although very similar; carina as in A. virginiensis, but teeth a bit larger; vesica with one well-developed cornutus at the end and a much reduced one in the middle; cephalic margin of proximal end angular (ROM gen. prep. 3-034).

Female (fig. 8i): Ovipositor valves of a peculiar shape, much wider at the base than at the apex, apex not rounded but linear; lobuli vaginales high; sterigma of medium height; antrum showing marked relation to A. virginiensis, appearing in lateral view as an oversized oval connection between ostium bursae and bursa copulatrix which is connected by a very short ductus bursae; ostium bursae strongly circumscribed; ductus seminalis connected laterally in first quarter of antrum; bursa copulatrix round; signum, if present, very small, round (ROM gen. prep. 3-084).

# **EGG**

Yellow when deposited, becoming various shades of brown through development. Length  $1.7\,$  mm, width  $1.5\,$  mm, height  $1\,$  mm.

# LARVA (pl. I, fig. 7)

The following description is based on material from R. O. Kendall. Data on earlier instars are too inadequate and fragmentary to give at the present time.

Fifth instar: Body, headcapsule, and anal plate beige brown; horns on second thoracic segment smooth with only a few short, thin setae, only slightly clubbed, 5 mm long; on each segment a black saddle from spiracle to spiracle, the width of a segment, sometimes so much expanded that only fragments of the beige brown body color are visible between; on the saddle a pattern of porcelain white smaller and larger ecrescences, the latter with a small seta at the end of each; a subdorsal, supraspiracular and subspiracular row of white thorns with a small seta on top, in some spcimens stronger and more or less blackened; spiracles black; an extended black ring around the outer half of the legs or prolegs, a similar patch on segments without prolegs, with small and medium white ecrescences, the latter ones with a small seta at the end of each; a thin dorsal line; a light beige ventral one; the eighth segment with one subdorso-lateral more prominent thorn on each side; on the ninth segment a dorsal one; length 43 to 47 mm.

## PUPA (pl. VII, fig. 10)

Dark reddish brown; 25 mm long; stout; cremaster very short; evenly protruding; similar to A. oslari but with a wider base.

# DISTRIBUTION

From the figures in Draudt (1930) (see discussion below) we have the record of Tamaulipas. Numerous other widespread records show the species to occur from Mexican states bordering the United States south to Chiapas. Since the latter locality (Comitan) is only ca. 50 km from the Guatemala border, the species is probably also present in that country.

### TYPE MATERIAL

The male holotype was collected in Santa Ana, Chihuahua, Mexico by Buchan-Hepburn according to the original description. This specimen was examined by the junior author at the BMNH. The type locality remains unclear because at least five places in Chihuahua are named Santa Ana.

# BIOLOGY AND REMARKS

According to Draudt (1930) a paper by A. Dampf was to be published describing the immature stages, but this paper could not be located and presumably was never published. Although Draudt treated Dampf's material as A. leucostygma, the color figures (pl. 142f) leave no doubt that the species was actually A. assimilis. The Dampf material in Draudt's collection was destroyed in World War II (Franz Daniel, Zool. Samml. Bayerisch. Staates, in litt.).

Although Ferguson (1971: 64) remarked that this species is known only from the unique male type, we found numerous specimens available for study as listed under material examined. Inadequate series are available however to clarify apparent differences between northern and southern populations. A series from Chihuahua reared from larvae collected on *Quercus grisea* by Roy and Connie Kendall agrees well with the holotype, as does the male seen from Durango. Specimens from other localities are larger with less intensely marked postmedian lines in the males, and there exists more variation among the series from Chihuahua. The latter also exhibit more gray clouding in the wings.

The nearly mature larvae collected by the Kendalls were found in late September and adults emerged the following summer. Adults from Oaxaca were taken in September, from Chiapas in June, from San Luis Potosi in April and from Veracruz in July. Apparently these scant data suggest the species is univoltine in the northern part of its range and bivoltine in the southern part. The immature stages are herein described and figured for the first time.

### MATERIAL EXAMINED

MEXICO. CHIAPAS: Comitan (Lemaire Coll., Peigler Coll., ROM, all ex Lemaire Coll.). CHIHUAHUA: Santa Ana (BMNH); near Creel, 2200 m (Kendall Coll., Lemaire Coll., Peigler Coll., all ex Kendall Coll.). DURANGO: near Durango City (BMNH). OAXACA: no additional locality data (Lemaire Coll.). SAN LUIS POTOSI: Posada El Sol, Tamazunchale (IBM), Tamazunchale (AMNH, UCal). VERACRUZ: Poza Rica (UCal). Examined 20+ males, 30+ females; dissected 3 males, 1 female.

### Anisota dissimilis (Boisduval)

Adelocephala dissimilis Boisduval, 1872: 93.

Dryocampa dissimilis; Druce, 1886: 170, pl. 15; Kirby, 1892: 740.

Anisota dissimilis; Packard, 1905: 116; Bouvier, 1927: 273; ibid., 1931: 21; Schuessler, 1936: 212; Draudt, 1930: 814, pl. 142g; Hoffmann, 1942: 245;

Ferguson, 1971: 64; Lemaire, 1976: 48.

Anisota suprema Henry Edwards, 1884: 16; Schaus, 1884: 102 (larva); Druce 1897: 415; Packard, 1905: 115, pl. 19, figs. 7, 7a; Bouvier, 1927: 273; Schuessler, 1936: 218; synonymized by Draudt, 1930: 814; type locality: Jalapa, Veracruz, Mexico.

# ADULT

Male (pl. III, fig. 10): Head and thorax mahogany brown; abdomen blackish brown; legs blackish; basal area of forewings and posterior tuft of abdomen mahogany brown; terminal area with purplish overtone; venation on forewings blackish; hindwings dark blackish brown; postmedian line blackish, well-marked on forewings only; white discal spot medium sized; underside of all four wings alike, with reddish mahogany basal areas, terminal area with purplish overtone; postmedian line and venation well-pronounced and blackish on all wings. Outer margin of forewings slightly rounded, of hindwings rounded. Length of forewing 22-27 mm (12 measured). In some specimens the hindwings are not as deeply colored as usual; in these the venation shows up in the normal darker coloration.

Female (pl. III, fig. 11): Much lighter colored; head and thorax ochreous brown; abdomen blackish brown, the segments outlined in ochreous brown; legs blackish; forewings leathery brown, or orange to yellowish brown; hindwings suffused slightly with color of male hindwings in much diluted form or with a pinkish hue; venation on forewings reddish brown, on hindwings blackish; postmedian line well-marked on all wings, blackish; white discal spot larger than in male; underside of both wings with basal area rosy brown, terminal area like hindwings above, postmedian lines broad and blackish. Outer margin as in male. Length of forewing 32-37 mm (23 measured).

Head: Laterofrontal suture strongly visible. Frontal protuberance transverse, insignificant. Male antenna with 18 rami. Posterior aspect of head showing well-developed short triangular lateral projections, apex straight.

Legs: Epiphysis found only in male, very thin, length ¾ that of tibia, rod-shaped, covered with extremely short hairs at apex, with some long ones marginally.

#### GENITALIA

Male (fig. 10a): Uncus distinctly M-shaped, straight laterally, two separate sclerotized elevations on each arm; gnathos broad, triangular shield with straight lateral sides cephalad; valves of the usual form with specific peculiarities, ventral part of bifurcation a sharp, heavily chitinized thorn, dorsal one a bit longer, much wider; free anellus a wide evenly-shaped heart crescent with very short apices. Aedoeagus only weakly chitinized, straight and short, carina without cornuti, vesica also short but with cornuti, one in middle, the other minutely serrate and at the apex. (Gen. prep. no. 349 Michener, AMNH).

Female (fig. 10b): Ovipositor valves rounded at apex; lobuli vaginales very low, sterigma as usual; antrum short, ending in an irregular triangular shape; ductus bursae bent abruptly laterad at half length, then again cephalad where oblong bursa copulatrix is attached; no signum; ductus seminalis connected at beginning of antrum, ventro-medially (unusual). (Gen. prep. no. 350 Michener, AMNH).

#### EGG

Unknown to us.

### LARVA

No specimens were available for the present study, nor do any illustrations exist. The following description is summarized from Schaus (1884). Length ca. 60 mm; head, mesothoracic segment and anal segment yellow; other segments black dorsally, the metathoracic one having a yellowish subdorsal line; mesothoracic segment also mrked with four small black spots dorsally and one laterally. Beginning on the metathoracic segment four dorsal rows and one lateral row of short pointed black spines occur. The two inner dorsal spines on the metathoracic segment are, on the contrary, long and blunt at the tips; small patches of white spots on thoracic segments; color of first three abdominal segments yellow, the following ones reddish brown; black spots between abdominal segments; prolegs yellowish; abdominal segments 2, 3, and 4 yellow ventrally, the succeeding ones having a yellow line; "centrally and exteriorly a large black spot". Anal segment covered with spiny ecrescences. Young larvae differ in being greenish black dorsally and without the patches of white spots.

# PUPA (pl. VII, fig. 11)

Two dried pupae were available for study. End of pupa gradually tapering; cremaster long, bifurcated; bifurcation short and strong; on both sides of thorax a patch of very heavy sclerotization with irregularly arranged pits; form of patch and arrangement of holes seem to be specific but more pupae should be studied.

# DISTRIBUTION

Aside from the records given below under material we examined, there is the additional one of Guatemala (Bouvier, 1931: 21) and the remarks of Hoffmann (1942): "Tierras fria y templada de Veracruz, Montanas de Hidalgo, Puebla y Oaxaca. Sierra Volcanica Transversal. Guanajuato. Durango."

## TYPE MATERIAL

Type locality: Oaxaca, Mexico (not specified as to Oaxaca State or Oaxaca City). We have seen the pair of cotypes from the Boisduval collection in the MNHN in Paris. We herein designate the male as lectotype and the female paralectotype.

The holotype male of A. suprema we have seen in the AMNH.

### BIOLOGY AND REMARKS

The food was reported to be oak (Schaus, 1884). The insect is widespread in central and southern Mexico at moderate to high elevations and probably extends into Guatemala. It is said to be abundant at Jalapa (Packard, 1905), but the junior author failed to find it there on a brief trip through that area.

It is not possible to say much about the flight times since the few records are widely scattered geographically. Records for Chiapas of March, May, June, and July suggest two broods. Also it has been taken in Chimalapa in September, in Jalapa in May, and in Zacualpan in June. The species is probably not sympatric with its ally to the north, A. punctata.

A male from Jalapa (pl. III, fig. 12) in the MHNM from the Roberto Mueller collection is unusually suffused with black. It appears more normal underneath. Good colored figures of both sexes are given by Packard (1905), Druce (1886), and Draudt (1930).

As we stated under "Intrageneric Classification and Phylogeny" this species appears to be the most primitive species in the genus, the geographical distribution supporting this idea.

The abdomen has a blackish coloring of scales but the intersegmental membranes are bright orange. Several saturniids in the Hemileucinae (e.g., *Dirphia, Molippa*, etc.) show this warning coloration of orange and dark stripes, curling the abdomen when disturbed to expose the orange.

# MATERIAL EXAMINED

MEXICO. CHIAPAS: Rancho San Ramon near Mun Ochuc (= Oxchuc) (LACM, Lemaire Coll., Peigler Coll.). DURANGO: Chilpancingo Palos Colorados (AMNH). DISTRITO FEDERAL: Mexico City (AMNH). HIDALGO: Zacualpan (AMNH, ROM). OAXACA: (AMNH, ROM, MNHN), Chimalapa (Lemaire Coll.). PUEBLA: "Manzanilla" (AMNH), Coatepec (USNM). VERACRUZ: Jalapa (= Xalapa) (AMNH, MHNM), Mirador (ranch of R. Mueller near Cordoba) (MHNM), Orizaba (USNM). Examined 15 males, 27 females, used pair of dissections of Michener (AMNH).

## Anisota oslari W. Rothschild

Anisota oslari Rothschild, 1907: 432; Jordan, 1908: pl. 10: 13; Bouvier, 1931: 19; Schuessler, 1936: 212; Draudt, 1930: 814; Hoffmann, 1942: 245; Ferguson, 1971: 78; Lemaire, 1976: 47.

Anisota skinneri Biederman, 1908: 77; Barnes and McDunnough, 1910: 400 (biology); - synonymized: Barnes and McDunnough, 1917: 28; type locality: "Arizona".

Anisota neomexicana Brehme, 1909: 324; synonymized: Barnes and McDunnough, 1917: 28; type locality: Fort Wingate, New Mexico.

## ADULT

Male (pl. IV, fig. 9): Head, thorax, abdomen orange-ochreous; legs wine-red; forewings dark reddish mahogany; no hyaline patch; hindwings deep wine-red; postmedian line very slightly marked; white discal spot variable in size; forewings triangular with an acute apex; underside of both wings wine-red, darker in forewing basal area; lighter apically. Outer margin of both wings usually rather straight. Length of forewing 23-29 mm (12 specimens measured).

Female (pl. IV, fig. 10): Head, thorax, abdomen, legs light ochreous brown; forewings beige; hindwings light wine with mauve tinge; postmedian line broad and slate colored; white discal spot variable in size; underside of wings beige with mauve tinge, basal area of forewings with light wine-red shading. Outer margin of wings rounded. Length of forewing 30-41 mm (11 specimens measured).

Head: Laterofrontal suture visible. Frontal protuberance transverse, not prominent but somewhat more produced than in the other species of the group. Male antenna with 19 rami. Posterior aspect of head shows a scalloped outline; one well developed lateral process together with one large rounded process differentiates A. oslari from all other species of the genus.

Legs: Epiphysis slender, half as long as tibia, densely covered with very short hairs, laterally and at apex a few longer ones; observed only in the male. Empodium with one tubercle bearing a medium-sized seta.

#### GENITALIA

Male (fig. 6a): Uncus quite broadly M-shaped, apices heavily sclerotized; gnathos broad with rounded apex, margins somewhat sinuate; midsection of lateral margin of valves curved, upper and lower sections straight; parts of bifurcation of

unequal length, dorsal part not chitinized, much wider than ventral ones; free annellus a heart shaped crescent. Aedoeagus very short, straight, carina with a small tooth on ventral edge; vesica with one well-developed cornutus at mid-length; the usually strong cornutus at apex rudimentary, a very slight chitinization of edges of triangular apex so that A. oslari has only one real cornutus on vesica. (Gen. prep. ROM 3-032).

Female (fig. 8h): Ovipositor valves broadly rounded, whole structure large, "angular"; lobuli vaginales as in A. finlaysoni; sterigma more straight; antrum absent; ductus bursae not chitinized, making an abrupt 90° turn laterally where bursa connected; ductus seminalis connected in upper fifth of ductus bursae laterally. (Gen. prep. ROM 3-038).

### EGG

Smooth, flatly elliptical, pale yellow, 2 mm by 1.8 mm by 1.2 mm; hatching after about 14 days.

LARVA (pl. I, fig. 8)

The following is taken from Barnes and McDunnough (1910):

First instar: Body at hatching yellowish, later greenish-grey, legs black. Length 3 mm.

Second instar: Head red, body olive brown, turning later red-brown; skin granulated; all tubercles and spines shiny black. Horns on second thoracic segment 2.3 mm long, covered with minute bristles, apex slightly bifurcate. Spiracles black, legs black. Length 9 mm.

Third instar: Head orange-red with fine network of darker lines, sparsely covered with very minute setae. Body brick-red. Skin granulated with a well developed lateral fold. Horns on second thoracic segment slightly recurved, 5.5 mm long. Spiracles black; legs black. Length 19 mm.

Fourth instar: Head and body as in previous instar. Mesothoracic horns 8 mm. Spiracles, prolegs black. Length 38-50 mm, presumably according to the sex.

Fifth instar: Head reddish-brown, shiny; body dark brick-red, very strongly granulated, with broken yellow subdorsal and spiracular stripes, the latter being chiefly confined to a yellow patch about spiracle. Horns on mesothorax only 5.5 mm. Spiracles black; legs pale red. Length 50-65 mm. Material in alcohol from Texas received from R. O. Kendall and from Arizona received from E. M. Brown was used to verify this description. Headcapsule shown in fig. 4e, suranal plate in fig. 2e.

PUPA (pl. VIII, fig. 3)

Material from Texas and from Arizona was available for study. Dark brown; posterior end gradually narrowing, margins proceeding smoothly from segment to segment; cremaster long, bifurcated; parts of bifurcation thin and longer than in A. dissimilis; the patches on the mesothorax have a different form and pattern of shallow pits than in A. dissimilis.

# DISTRIBUTION

The species is known from southeastern Arizona, New Mexico, west Texas and Sonora. In fact it seems that A. oslari, as so many other Lepidoptera found in Arizona, New Mexico and Texas, has its origin in Mexico. Ferguson (1971) says that Texas specimens were of a more recent date, however, in AMNH there is a female specimen from Sunny Glen Ranch, 1500 m, Brewster Co., Texas, collected on 10 June 1926. In the same collection is also a male and a female with the label

"Janeiro" and no other data from the Frank Johnson collection. This locality could not be identified.

## TYPE MATERIAL

Type locality: Nogales, Santa Cruz County, Arizona. Additional type data: described from 2 females obtained by E. J. Oslar in July 1903 "from chrysalids dug from the roots of the century or mescal plant". Location of cotypes: British Museum (Nat. Hist.). We hereby designate one female (dated 10 July 1903) as lectotype and the other as paralectotype; these specimens were examined by the junior author.

For A. skinneri a lectotype was designated by Ferguson (1971); it is the specimen which was labelled as the male type in USNM.

For A. neomexicana a lectotype was selected with F. H. Rindge from among the cotypes in AMNH and is hereby designated: male, New Mexico, 28 June, no year, ex coll. J. A. Grossbeck.

## BIOLOGY AND REMARKS

Ferguson (1971: 79) suggested that A. oslari might be a junior synonym of A. assimilis but the true identity of the latter species was uncertain to him. Ample material of A. assimilis is now available to clarify this uncertainty.

Earll M. Brown of San Diego has reared larvae of A. oslari from Arizona on Quercus kelloggii in California. According to Biederman (1908) the food is "black (live) oak", but we are unsure which oak species was meant. Larvae can probably be collected on most oaks where the moth occurs. As far as we know, our figure of the larva is the first one to be published.

The males are diurnal, flying during midday. Although they lack transparent patches on the forewings, they are undoubtedly effective mimics of wasps with their rapid flight and reddish orange coloration. The females are nocturnal and attracted to light. There is one generation annually, with adults flying in late summer or early fall, and larvae found in late fall. Reared material may emerge in early summer.

The males show several color forms from light mauve (as in females) to dark wine (as figured) and dark slate gray. Usually, the forewings and hindwings differ slightly in color, in both sexes. The color forms coincide to those of *A. assimilis*. The male and female figured by Ferguson (1971: pl. 5, figs. 25, 26) are very typical representatives for the species.

# MATERIAL EXAMINED

MEXICO. SONORA: not seen, reported by Hoffmann, 1942. UNITED STATES. ARIZONA: no other data (AMNH, CalAcSci); Garces (CM); Madera Canyon, Santa Rita Mountains (LACM); Nogales (CalAcSci, LACM); Palmerlee (CM); Pena Blanca Lake, Santa Cruz County (BPBM, Peigler Coll., ROM); Sonoita Creek, Santa Cruz County, S. of Patagonia (LACM); Sunnyside, Huachuca Mountains (LACM); Texas Canyon, Chiricahua Mountains (CNC). NEW MEXICO: no other data (AMNH, CalAcSci, FMNH, ROM); Fort Wingate (AMNH, CM, CNC, FMNH, LACM, USNM); Frijoles Canyon (AMNH); Jenny Springs (CM); Jimez Springs (CNC). TEXAS: Fort Davis (USNM); Musquiz Canyon, Jeff Davis County (ROM); Nickel Creek, Guadelupe Mountains (USNM); Sunny Glen Ranch (AMNH). Examined 58 males, 64 females, dissected 1 male and 2 females.

# Anisota punctata Riotte & Peigler, New Species

Anisota punctata Riotte & Peigler, 1980: on this page.

### ADULT

Male: unknown. It is expected that the male is nocturnal and resembles the male of A. dissimilis somewhat in appearance, but with many small dark spots on all wings.

Female (pl. III, figs. 8-9): Head, thorax, abdomen below ochreous brown, legs with a purplish hue; abdomen above with an olive hue; forewings leathery brown with numerous large spots of dark scales; hindwings purplish pink with some dark scales and a slight marginal border of leathery brown; postmedian line straight, very well perceptible on both wings, dark mauve; white discal spot very large; underside of wings rosy brown with strong sprinkling of black spots, especially apically on forewing and entire hindwings. Outer margin of forewings straight, of hindwings only slightly rounded. Length of forewing 37 mm. Specimen not dissected because it is unique.

# EGG, LARVA, PUPA

Unknown.

## DISTRIBUTION

Known only from the type locality but probably occurring in other northern Mexican states at appropriate elevations in the same mountain range.

## TYPE MATERIAL

Type locality: 27 km west of Linares, Nuevo Leon, Mexico. Known only from the single holotype female collected at this locality on 23 July 1976 at 2100 hrs by R. S. Peigler. The holotype is deposited in the AMNH in New York City.

## BIOLOGY AND REMARKS

The holotype was collected on a trip into Mexico sponsored by the Entomology Department of Texas A&M University, of which the junior author was a member. On 23 July 1976 an ultraviolet light in conjunction with a Coleman lantern was run on a sheet and the moth arrived at this light source two hours after sunset. No other specimens of *Anisota* were collected on the entire trip. The female was kept alive in a jar with oak leaves but died the following evening, unfortunately without depositing any ova.

The following summer the junior author returned to the same locality and ran the same lights for three consecutive nights (22-24 July 1977) but no additional specimens were obtained. That season had been unusually dry; a stream alongside the collecting site was dry, whereas it had been flowing in July 1976. Several species of Saturniidae and Sphingidae taken there in 1976 were not seen in 1977. The habitat of the type locality is forested. It lies in the foothills of the Sierra Madre Oriental. Pressed specimens of the oaks growing at the type locality were sent to John M. Tucker, Department of Botany, University of California, Davis, California. Dr. Tucker, an authority on New World oaks, made the following determinations:

Note Added in press: The LACM has a female of this new species, apparently recently donated, which is said to agree entirely with our figures of the holotype. The data for the specimen are: MEXICO, San Luis Potosi, El Narzanjo, 4 August 1975, Terry W. Taylor. There is not time to borrow the specimen and designate it a paratype before publication.

Quercus canbyi Trel., Q. fusiformis Small, Q. polymorpha Schl. & Cham. The first species has a high density in the area and with its large, tender, non-pubescent leaves, may be the primary host of A. punctata.

### PELLUCIDA GROUP

# Anisota discolor Ferguson New Status

Anisota virginiensis discolor Ferguson, 1971: 83; Lemaire, 1976: 47. ADULT

Male (pl. IV, fig. 6): Sexual dimorphism strongly developed. Head, abdomen, fore- and hindwings above sepia brown with a very slight purplish hue apically on the forewings; head, abdomen, legs, fore- and hindwings beneath predominantly of a greenish brass color, however, on the forewings apically and on the hindwings along the postmedian line and from wingbase to tornus purplish shades, on the forewings the veins are conspicuously overlaid by the greenish brass color; sprinkling with dark scales not observed in this species of the group; postmedian line on the forewings well, on the hindwings only slightly perceptible; hyaline patch not very extended; white discal spot medium sized; outer margin of forewings rounded, of hindwings almost straight. Length of forewing 18 mm (10 specimens measured).

Female (pl. IV, fig. 5): Head, abdomen, fore- and hindwings above almost unicolorous fawn with only very slightly purplish apically (fresh specimens tend to have a greenish shade over the entire wings); head, abdomen and legs beneath orange; fore- and hindwings beneath basically light purplish, strongly overlaid with greenish, ochreous orange; postmedian lines on both wings, above and beneath, well marked, purplish; white discal spot medium sized; only very few and very small dark scales on the forewings above costally; outer margin of forewings slightly, of hindwings strongly rounded. Length of forewing 27 mm (10 specimens measured).

Head: Laterofrontal suture very conspicuous, wide; frontal protuberance well developed and protruding. Male antenna with 14 to 15 rami. Posterior aspect of head pentagonal, laterally one conspicuous, round process.

Legs: Epiphysis dorsally strongly convex, ventrally straight, ending in point, covered with very short bristles, length little more than half of tibia. Epiphysis may be different in one and the same specimen on left and right leg, dorsally and ventrally straight and of even width, ending in blunt ending, length a little less than half of tibia; in some specimens epiphysis may be rudimentary, very thin, hardly half length of tibia; not observed in female; empodium one tubercle with slender thin seta; at end of anterior tibia spines normally developed, i.e., one strong one and one lesser.

# **GENITALIA**

Male (fig. 7f): Squarish; uncus wide M; gnathos sometimes with waving sides. Mostly a very broad round shield; bifurcations of equal length; interior angle of valve pointedly elongated; free annellus long, round tube with somewhat heartformed opening; aedoeagus rounded, more narrow than in A. virginiensis but a little wider than in A. pellucida; proximal end straight; carina prolongation of main body of aedoeagus; row of small teeth on carina; vesica with very prominent apical cornutus with teethed edge; there was no small, rudimentary second sclerite in 6 dissected males from Texas, however, such sclerite was often found in specimens of

A. virginiensis from Pennsylvania. (Gen. prep. ROM 3-164).

Female (fig. 9d): Ovipositor valves tapering off apically, of unusual form; lobuli postvaginales high, antevaginales very low; antrum like strong triangular funnel, connecting ostium bursae and strong, short, slightly oblique ductus bursae which has in its first third laterally strongly sclerotized ecrescenses; ductus seminalis attached at beginning of ductus bursae posterior-laterally; bursa copulatrix very slightly bent off ductus bursae, rounded oval, no signum, covered with fine network. (Gen. prep. ROM 3-051).

EGG (The following descriptions of egg and larvae—first to fourth instar—by C. Lemaire).

Yellow changing into orange and brown.

LARVA (pl. I. fig. 12)

First instar: Body color yellowish green, slightly blackish; very near to second instar of A. senatoria; headcapsule and thoracic legs black.

Second instar: Body color dingy greenish-yellowish; headcapsule and thoracic legs black.

Third instar: Body color dark olive brown; headcapsule beige-brown; thoracic legs black; prolegs olive; subdorsal and supraspiracular lines rose brown; two very slight infraspiracular whitish lines.

Fourth instar: Body color blackish brown; headcapsule beige-brown; thoracic legs greenish with black apex; prolegs olive black; white granulation not dense over body; subdorsal and infraspiracular lines purplish brown.

Fifth instar: Body color beige-brown; headcapsule, anal plate, thoracic legs of same color; white granulation not too dense over body; dorsal line purplish brown; of same color also wider subdorsal, supraspiracular and subspiracular bands; a spiracular waved line of same color; spiracles black with no border; horns on thoracic segment II clubbed, 8 mm long; length of fifth instar larva 42 mm. Headcapsule shown in fig. 5f, suranal plate in fig. 3f.

PUPA (pl. VIII, fig. 2)

Blackish brown, similar to that of A. virginiensis but the bifurcation perceptibly straighter and longer, even more so than in A. pellucida.

## DISTRIBUTION

This species was recently described from a series of specimens from several localities in eastern Texas. We now have records from Oklahoma (from P. Loy) and Louisiana (from R. O. Kendall); the species is probably only present in the western parts of Louisiana since we found it was replaced by A. pellucida at Choudrant and Baton Rouge. It is recorded in Texas as far northwest as Hamilton and as far southwest as Giddings. It is commoner than either A. fuscosa or A. senatoria in the grassland prairies between the Edwards Plateau and the forested areas of eastern Texas.

# TYPE MATERIAL

Type locality: Spring, Harris County, Texas. Location of type: United States National Museum, type no. 71496. Additional type data: female holotype, labelled Spring, Harris County, Texas, 27 August 1963, A. and M. E. Blanchard.

#### BIOLOGY AND REMARKS

There are two generations per year but the main one is the later one. Many overwintering pupae probably do not produce adults until the flight time of the

second brood. These flight times occur in late June to July and late August through all of September. Larvae can be collected easily in eastern Texas from late September to early November, some years more commonly found.

The male flies at midday. Their coloration is a smoky brown somewhat as males of A. finlaysoni but with more robust and thickly scaled wings. Some with the wine red coloring of A. pellucida occur occasionally. One male was attracted to a calling female in College Station, Texas, on 31 August 1978 at 1240 hrs (CDT). A diurnal sphingid (Hemaris sp.) also appeared but an attempt to capture it failed. This attraction was not surprising because Dominick (1974) had similar experiences with males of the sphingid Amphion nessus (Cramer) coming to females of A. pellucida in South Carolina.

In the females there is much more color variation than in either A. pellucida or A. virginiensis. Some are reddish or orangish as in those two species but most are "coffee-with-cream" colored. The postmedian area may be very purplish or scarcely contrasting from the median area.

Records for foodplants include *Quercus nigra* in Giddings, *Q. macrocarpa* in Hamilton, *Q. stellata* most often in College Station, and in eastern Texas usually the same oaks selected in the Atlantic States by other *Anisota*, namely *Q. velutina*, *Q. nigra*, and *Q. falcata* but also *Q. marilandica*. Although *Q. virginiana* grows commonly in College Station, no larvae of *Anisota* have been found on it by the junior author in three seasons.

# MATERIAL EXAMINED

UNITED STATES. LOUISIANA: no other data (CalAcSci); Vernon Parish (Kendall Coll.). OKLAHOMA: Claremore, Rogers Co. (AMNH). TEXAS: no other data (AMNH); Anderson Co. (Larva) (TAMU); Beaumont (LACM, TAMU); College Station (AMNH, BPBM, LACM, Lemaire Coll., Peigler Coll., ROM, TAMU, USNM); Giddings (LACM); Hamilton (AMNH); Houston (USNM); Huntsville State Park (LACM); Karnack (MSU); New Waverly (USNM); San Jacinto Co. (LACM); Spring (USNM); Stubblefield Lake in Walker Co. (AMNH, BMNH, BPBM, CNC, Peigler Coll., ROM); Town Bluff (USNM). Examined long series of males and females, dissected 5 males and 4 females.

# Anisota leucostygma Boisduval

Adelocephala leucostygma Boisduval, 1872: 85.

Adelocephala leucostigma; Druce, 1886: 171.

Anisota leucostygma; Bouvier, 1927: 273; ibid., 1931: 18; Draudt, 1930: 813; Hoffmann, 1942: 245; Ferguson, 1971: 64; Lemaire, 1976: 47.

# ADULT

Male: unknown. It is expected to be diurnal.

Female (pl. IV, fig. 8): Head and thorax reddish orange; legs and abdomen lighter orange; forewings reddish orange interiorly of postmedian line, golden brown with a very light hue of slate color exteriorly of postmedian line; this line very well developed on both wings; white discal spot large (as name implies); hindwings reddish orange; only sprinkled slightly with dark scales on apical area of forewings; underside of wings reddish orange. Outer margin of both wings evenly rounded. Length of forewing 31 mm.

## **GENITALIA**

Female (fig. 8g): Ovipositor valves not too large; sterigma very wide; lamellae

postvaginales not too high; lamellae antevaginales laterally strongly expressed, not too high; ostium bursae not very wide, reaching into ductus bursae like hook (see illustration); antrum not too pronounced; ductus bursae caudally becoming very wide, narrowing considerably cephalad before bursa copulatrix which is round and attached without turn; signum small, round; surface of bursa copulatrix with net-like pattern; apophyses very strongly developed; ductus seminalis attaching at dorsal side of antrum. (Gen. prep. ROM 3-082, now in Paris Museum).

# EGG, LARVA, PUPA

Unknown.

## DISTRIBUTION

Boisduval (1872: 86) says: "Nous avons recu cette espece de Guatemala et d'Oaxaca". The specimen described above is the only one extant. It has no locality label, except Boisduval's first identification label stating only "Mexique".

### TYPE MATERIAL

The one extant specimen passed through the collections of Charles Oberthuer and Philipon before becoming permanent property of the MNHN in Paris. Bouvier (1931: 18) declares: "D'apres Charles Oberthuer, la femelle de la collection Philipon est le type meme de leucostygma; elle porte l'etiquette suivante ecrite de la main de Boisduval: "Adelocephala stygma, Mexique." Dans sa description, en effet, Boisduval rapproche son espece de stigma." What Bouvier did we would call today the "designation of a lectotype", and with this the case may rest.

The labels on the specimen read: 1) handwriting of Boisduval: Adelocephala Stygma B Mexique; 2) handwriting of Oberthuer: Adelocephala Leucostygma, Boisduv. (Annal. Soc. Entom. Belgique, 1871-72, pages 85, 86, femelle, typicum specimen Boisduvalianum; 3) handwriting of Bouvier: Anisota leucostygma Boisd. femelle type + printed: E. L. Bouvier + handwritten: ver. (ified).

# REMARKS

If there were not the unmistakable assertion of Oberthuer and the declaration of Bouvier for the identity of A. leucostygma, and if the genitalia of the unique specimen were not so impressively different from those of the three other species belonging to the same group, one could perhaps understand that entomologists are tempted to consider A. leucostygma as a mislabelled specimen from somewhere in the southern United States. However, one has to be very careful with unique specimens. A. punctata is a unique female from Mexico, too, and A. assimilis was until very recently a unique male from Mexico in the British Museum (N.H.). In the latter case various negative suppositions had been aired but finally the species was abundantly relocated in Chihuahua. This may very well happen to A. leucostygma. One should also consider the fact that the specimen has on the original Boisduval label as locality only "Mexique", and that at the time when the specimen came into the possession of Boisduval, about the middle of the 19th century, Mexico was still commonly understood by Europeans to extend much farther to the north than now and to cover all of Spanish speaking North America. We might disregard the locality designations in Boisduval's original description: Guatemala and Oaxaca. Also here political boundaries in those days were other than they are now. The southern states of today Mexico did belong to Guatemala. As far as then Oaxaca is concerned Boisduval may have been influenced by the locality from where he received his Adelocephala dissimilis (1871: 93), but one should not doubt his handwritten label

"Mexique" (sensu lato). One should here consider other cases of "unbelievable" species, like the Hawaiian hawkmoth *Tinostoma smaragditis* (Meyrick) which, because it just looked so strange, was green like *Eumorpha labruscae* from Brazil, was by later workers suspected not to be Hawaiian at all but was thought to have been sent in the mail from Brazil to Hawaii and then given to Perkins who, however, expressly says that he received the specimen from persons who had found it in their house on Kaua'i. Today, also very recently, several specimens of this indigenous insect are known and in collections. Therefore we should have some trust into the solid, early workers, and we can only hope that much better and subsequent collecting in Mexico will finally also turn up again *A. leucostygma*.

Specimens of A. assimilis reared from Tamaulipas by Dampf were assumed by Draudt (1930) to be A. leucostygma but his figures of Dampf's material (destroyed in war action) clearly show A. assimilis. Bouvier (1931) and Hoffmann (1942) therefore erroneously reported A. leucostygma as being from Tamaulipas.

In some of the literature it can be found that Boisduval considered his A. leucostygma to be systematically close to A. stigma. Maybe so, as his handwritten label suggests. However, his original description of A. leucostygma shows that he then changed his mind in the right direction.

Druce (1886) reports only briefly about the species which he has not seen from Mexico and Guatemala. Bouvier (1927) then does not mention "Guatemala" anymore.

## MATERIAL EXAMINED

The one extant specimen of A. leucostygma was loaned to the senior author by P. E. C. Viette. It was then dissected and the genitalia show it to be very much distinct.

# Anisota pellucida (J. E. Smith)

Phalaena pellucida J. E. Smith, 1797: II: 115, pl. 58; - synonymized: Westwood, 1837.

Dryocampa virginiensis; Westwood, 1837: 24, pl. 13: 2.

Dryocampa pellucida; Harris, 1841: 293.

Anisota pellucida; Grote, 1864: 93; Packard, 1864: 385; Lemaire, 1976: 47.

Adelocephala pellucida; Boisduval, 1872: 87.

Anisota virginiensis; Packard, 1905: 103.

Anisota virginiensis sinulis Riotte, 1970: 89; - synonymized: Ferguson, 1971; type locality: Gainesville, Florida.

Anisota virginiensis pellucida; Ferguson, 1971: 82.

#### ADULT

Male (pl. IV, fig. 3): Sexual dimorphism strongly developed. Head, abdomen above, fore- and hindwings above very dark brownish wine-red; legs, abdomen below dark orange; in many specimens apically sprinkled with dark scales; postmedian line well perceptible on both wings, also on underside; white discal spot small; an ochreous-brown hue can be found on hindwings, thorax and dorsal part of abdomen, it is, however, very often very faint. Underside of hindwings very dark, mostly only at anal angle of hindwings and at costal margin of forewings dark orange-ochreous suffused. Outer margin of both wings in most specimens straight, in some even showing some convexity; anal angle of hindwings only very slightly rounded. Length of forewing 14-16 mm (25 specimens measured).

Female (pl. IV, fig. 4): Densely scaled; interior field dark orange brown; exterior

field mauve; head, thorax, abdomen dark orange brown; apically sprinkled with dark scales in many specimens; postmedian line strongly expressed; white discal spot not too large. Outer margin of both wings strongly rounded. Length of forewing 21-28 mm (25 specimens measured).

Head: Laterofrontal suture visible. Frontal protuberance reduced. Male antenna with 12 rami. Posterior aspect of head a smooth ellipsoid without lateral processes and in this quite distinct from other *Anisota* species.

Legs: Epiphysis observed only in males; light colored; slightly less than ½ of length of tibia; convex dorsally; straight laterally; ending in a point; only slightly covered with bristles. Empodium one small tubercle with one thin small seta. At end of anterior tibia only one strong apical spine, no second one.

### **GENITALIA**

Male (fig. 5d): Uncus W-shaped, wide, apices strongly sclerotized; gnathos a narrow, oblong shield, reminding of a sugar loaf; valves from a very broad base narrowing into unusual long processes; outer margin of valves in the middle strongly bent which renders them hexagonal; interior angle of valve more or less pointed, in some specimens even elongated into a veritable thornlike process. Aedoeagus rounded, short, carina long and wide; at apex with a row of small teeth; vesica with one apical cornutus; proximal end narrow and pointed. (Gen. prep. ROM 3-099).

Female (fig. 9c): Ovipositor valves not too large, rounded at apex, in dorsal view broader at base, in lateral view very angular, with blackish pigmentation; sterigma wide; lamella postvaginalis low, lamella antevaginalis almost only like margin of ostium bursae; this very wide posteriorly, then narrowing into ductus bursae like funnel; antrum not too pronounced; ductus bursae only slightly sclerotized, cephalad of antrum straight to the left ending in oblong bursa copulatrix; no signum but surface of bursa copulatrix with fine net like pattern; apophyses long and relatively strong; ductus seminalis attaching on dorsal side of antrum. (Gen. prep. ROM 3-053).

EGG

Orange; 1.1 x 1.4 x 0.8 mm.

LARVA (pl. I. vig. 11)

First instar: Body color beige-brown; dark brown broad dorsal stripe; fine spiracular dark brown lines; head blackish brown; thoracic horns smooth, finely bifurcated, black; inferiorly to lateral lines a yellowish patch around the scolus on each segment. Length of first instar larva: 5 mm.

Second instar: Body color olivish-brown; darker brown broad dorsal stripe; spiracular lines dark brown; supra- and subspiracular lines yellowish, fine; horns with thorns, finely bifurcated; head very dark reddish cherry brown. Length of second instar larvae: 7 mm.

Third instar: Body color dark olive brownish; dorsally darker; spiracular space bordered on both sides by yellowish-whitish broken fine lines; subspiracularly broad outstanding vermillion line (broken at segments); additional little white tubercles (also on suranal plate) everywhere; horns long, with secondary thorns, ends shortly bifurcated; on dorsum in middle thin darker olive line and subdorsally on each segment thin broken vermillion lines; head as before. Length of third instar larva: 12 mm.

Fourth instar: No change, except head now light brownish-beige. Length of fourth instar larva: 20 mm.

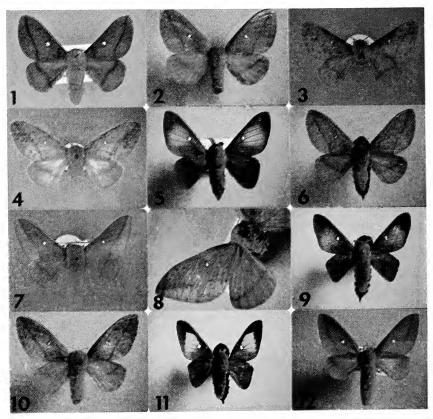


PLATE II. 1. Anisota stigma &, Clemson, South Carolina, reared ex ovo 21 July 1975 by J. C. E. Riotte (ROM). 2. A. stigma Q, Clemson, South Carolina, 7 July 1975, at light, R. S. Peigler and J. W. McCord (Peigler Coll.). 3. A. fuscosa & Leesville, Louisiana, ex larva 4 August 1960, R. O. & C. A. Kendall (ROM). 4. A. fuscosa ♀, same data as fig. 3 except date: 15 August 1960. 5. A. consularis &, St. Johns County, Florida, reared ex ovo 16 August 1974 by J. C. E. Riotte (ROM). 6. A. consularis ♀, Statesboro, Georgia, ex larva on Quercus falcata 8 July 1976, R. S. Peigler and J. W. McCord (ROM). 7.A. manitobensis & Pembina Valley, Manitoba, ex larva, 17 April 1953, F.I.S. (ROM). 8. A. manitobensis ♀, Waushara County, Wisconsin, 3 July 1936, C. Harrington (ROM ex Sieker Coll.). 9-10. A. peigleri ♂ X consularis ♀, hybrid pair, Greenville, South Carolina/ Statesboro, Georgia, 22 July 1977 and 17 September 1976, R. S. Peigler (ROM). 11-12. A. virginiensis ♂ X discolor ♀, hybrid pair, Pine Grove, Pennsylvania/Hamilton, Texas, 28 June and 20 July 1977, R. S. Peigler (Peigler Coll.).

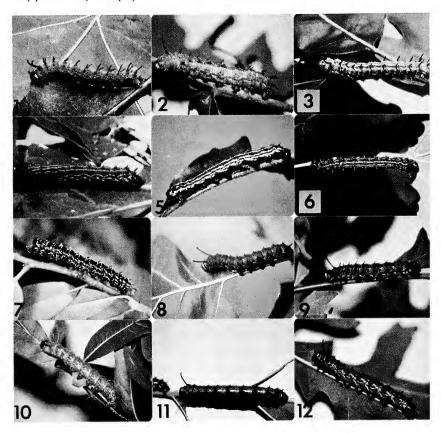


PLATE I. Mature larvae of Anisota. 1. A. stigma, Greenville, South Carolina. 2. A. fuscosa, Walker County, Texas. 3. A. consularis, St. Johns County, Florida. 4. A. senatoria, southeastern Michigan. 5. A. finlaysoni, Shannonville, Ontario. 6. A. peigleri, Clemson, South Carolina. 7. A. assimilis, Creel, Chihuahua. 8. A. oslari, Arizona. 9. A. peigleri & X consularis \( \beta \), hybrid. 10. A. virginiensis, Pine Grove, Pennsylvania. 11. A. pellucida, McClellanville, South Carolina. 12. A. discolor, Walker County, Texas.

N.B.: Plates I and II were inadvertantly transposed in the original color printing, and although out of order, they are properly numbered and labelled.

Fifth instar: No change, except for kind of silvery shine because of the many white tubercles all over body; lateral subdorsal lines a little thicker, vermillion; horns long (7-8 mm), black, somewhat roundly bent, without remarkable secondary thorns, ends no longer bifurcated; spiracular space not bordered anymore by anything. Length of fith instar larva: 35 mm. Headcapsule shown in fig. 5d, suranal plate in fig. 3d.

# PUPA (pl. VII, fig. 7)

Dark brown; not too spiny; cremaster heavy set, originating from broad base, short and wide, bifurcation long, almost entirely straight, not too pointed.

### DISTRIBUTION

This species ranges from coastal North Carolina deep into the Florida peninsula and across to Louisiana where it becomes parapatric with A. discolor. It is very common in coastal South Carolina through Florida, much less common in the piedmont of the former state. The presumed range into Tennessee, Arkansas and North Carolina where it probably contacts A. virginiensis needs elucidation.

#### TYPE MATERIAL

The name is based on Abbot's painting in J. E. Smith (1797: pl. 58). As this is only a vague basis for a taxonomic entity in the case concerned because of the extreme variation in the rendition of the plates in the various existing copies of the work in question, it was considered right to designate a neotype. As such was chosen the male holotype of Anisota virginiensis sinulis Riotte and with this the type locality fixed as Gainesville, Florida. Additional type data: taken 22 September 1955 by C. N. Patton in Gainesville, Florida. Location of neotype: Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture, Gainesville, Florida. In the said collection is also the female allotype of Anisota virginiensis sinulis Riotte, taken 21 September 1964 by J. W. Perry in Gainesville, Florida.

### BIOLOGY AND REMARKS

The junior author has found larvae on *Quercus nigra* in South Carolina, Georgia, Florida and Louisiana. That oak, along with *Q. falcata*, are favorite hosts throughout much of the range. D. Baggett collected larvae in northeastern Florida on *Q. myrtifolia* and *Q. imbricaria*. J. D. Solomon sent us larvae in alcohol from coastal Mississippi collected on *Q. nuttallii* and *Q. lyrata*. Larval colonies are small, averaging only about ten individuals by the time the last instar is reached, because females deposit fewer ova at each site than do those of other species groups.

The moth is double-brooded throughout its range but the flight times vary considerably with latitude. Records range from 11 April at Punta Gorda, Florida, to 3 October at Oneco, Florida, so there might possibly even be a third brood at these lowest latitudes. During the summer the pupal stage lasts only about two weeks. Dominick & Edwards (1971) and Solomon (1971) reported on the circadian sexual activity of the moths.

It should be remarked that the larva shown in J. E. Smith (1797: pl. 58) on Q. marilandica definitely represents the present species, although the adults are not well recognizable.

# MATERIAL EXAMINED

UNITED STATES. FLORIDA: no other data (AMHN, CNZ); Eglin (Hilton Coll.; Ft. Meade (FMNH); Gainesville (FSCA, LM, ROM); Indian River (AMNH);

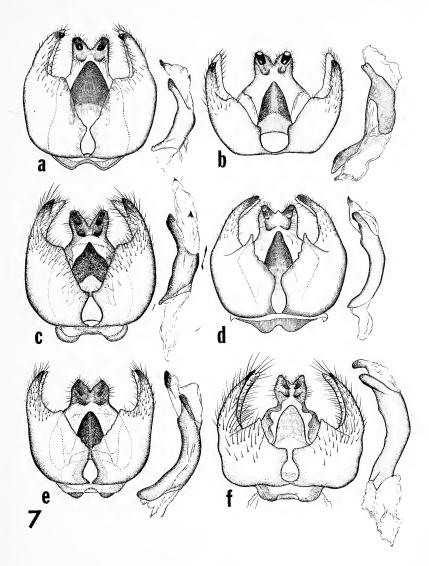


Fig. 7. Male genitalia, with aedoeagus removed and alongside: a. A. senatoria, b. A. peigleri, c. A. finlaysoni, d. A. pellucida, e. A. virginiensis, f. A. discolor.

Jupiter (AMNH); Largo (CNC); 5 km S. of Leesburg (FMNH); Oneco (AMNH); Orlando (AMNH); Parish (LM); Punta Gorda (FMNH); Swannee River State Park (LM); White Springs (BPBM). GEORGIA: Athens (CLU); Clarke Co. (CLU); Emory University (FSCA); Fish Eating Creek (FSCA); Statesboro (BPBM, LACM,

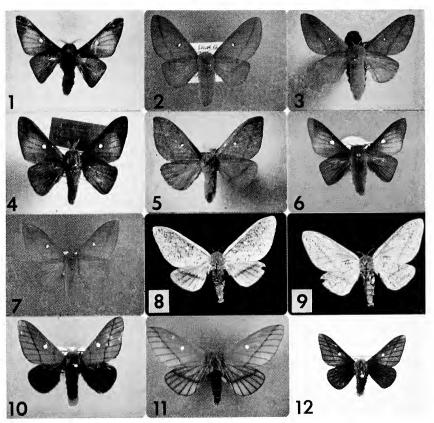


PLATE III. 1. A. peigleri ${\circlearrowleft}$ , Greenville, South Carolina, attracted 4:30 PM EDT on 7 July 1976 to a female of A. consularis, R. S. Peigler (Peigler Coll.). 2. A. peigleri Q, Clemson, South Carolina, reared ex ovo 12 July 1975 by J. C. E. Riotte (ROM). 3. A. peigleri Q, Clayton, Georgia, ex larva 18 May 1975, on Quercus velutina, R. S. Peigler and J. W. McCord. 4. A. senatoria , Neotype, Gibsland, Bienville Parish, Louisiana, 21 August 1976, at light at Interstate 20 rest area, R. S. Peigler (AMNH). 5. A. senatoria 9, same data as fig. 4 (Peigler Coll.). 6-7. A. finlaysoni & Q. Kingston, Ontario, 6 and 2 May 1970, J. C. E. Riotte (ROM), 8-9. A. punctata \( \begin{aligned} \text{q. upperside and} \end{aligned} \) underside, holotype, 27 km W Linares, Nuevo Leon, Mexico, 23 July 1976, at light, R. S. Peigler (AMH), 10. A. dissimilis o, Zacualpan, Mexico, June 1915 (ROM ex AMNH). 11. A. dissimilis 9, Oaxaca, Mexico, no date (ROM ex AMNH). 12. A. dissimilis ♂, Jalapa, Veracruz, May (MHNN), an unusually melanic male.

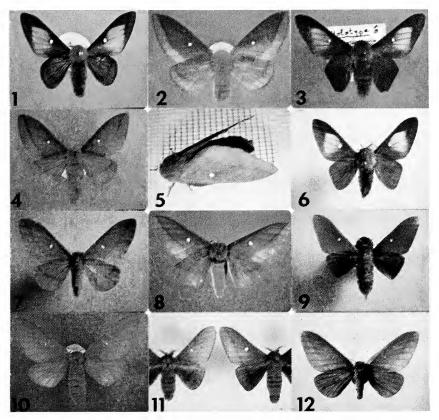


PLATE IV. 1. A. virginiensis ♂, Chaffeys Locks, Ontario, reared ex ovo 6 August 1970 by J. C. E. Riotte (ROM). 2. A. virginiensis Q, Rondeau Provincial Park, Ontario, 22 June 1965 (ROM), 3. A. pellucida &, holotype of A. virginiensis sinulis, neotype of A. pellucida, Gainesville, Florida, 22 September 1955, C. N. Patton (FSCA). 4. A. pellucida 9, McClellanville, South Carolina, reared ex ovo 1 September 1972 by J. C. E. Riotte (ROM). 5-6. A. discolor Q J, both College Station, Texas, reared 1976-1977 on Quercus pubescens in France by C. Lemaire (Lemaire Coll.), female in natural resting position. 7. A. discolor ♀, Claremore, Rogers County, Oklahoma, 19 August 1977, Peter Loy (AMNH). 8. A. leucostygma ♀, lectotype, Oaxaca, Mexico no date (MNHN). 9. A. oslari o, Pena Blanca Lake, Santa Cruz County, Arizona, reared on Quercus kelloggii by Earll M. Brown and emerged 23 June 1977 (Peigler Coll.). 10. A. oslari Q, Jeff Davis County, Texas, ex larva 13 August 1968, R. O. & C. A. Kendall (ROM). 11. A. assimilis & &, near Creel, Chihuahua, Mexico, ca. 2134 m, ex larva on Quercus grisea 26 May and 20 June 1979, R. O. & C. A. Kendall (Kendall Coll.). 12. A. assimilis 9, Comitan, Chiapas, Mexico, June 1963 (ROM ex Lemaire Coll.).

ROM); Stonehenge (CLU). LOUISIANA: no other data (CalAcSci); Baton Rouge (AMNH, LSU, ROM); Edgard (ACM); Harahan (CMZ); L. Charles (AMNH); Pointe Coupee Parish (LSU); Prairieville (BPBM, DPI, LACM, LSU); Sorrento (AMNH); Sunshine (AMNH). MISSISSIPPI: Aditon (ROM); Bovina (AMNH, BMNH, LACM); Clinton (AMNH); Pearl (ROM); Tupelo (LACM); Vicksburg (AMNH, LACM). NORTH CAROLINA: Carteret Co. (AMNH); Fontana (CM); Whiteville (Peigler Coll.). SOUTH CAROLINA: Clemson (LACM, Peigler Coll., ROM); Greenville (Peigler Coll.); McClellanville (ROM); Manning (AMNH, LACM, Lemaire Coll., ROM); Orangeburg (LACM, ROM); Pendleton (BMNH); Six Mile (Lemaire Coll.); Summerville (FSCA). Examined 30 males and 40 females, dissected 7 males and 7 females.

# Anisota virginiensis (Drury)

Bombyx virginiensis Drury, 1793: 23, pl. 13: 2.

Dryocampa virginiensis; Westwood 1837: 24, pl. 13: 2; Walker, 1855: 1496.

Anisota virginiensis; Grote, 1874: 261; Kirby, 1892: 739; Neumoegen and Dyar, 1895: 148; Dyar, 1896: 166; Beutenmueller, 1898: 440; Holland, 1903: 95, pl. 8: 9, 10; Packard, 1905: 102, pl. 20: 1-3 (adults), pl. 4: 1-5, pl. 5: 1-5, pl. 29: 1-1d, pl. 50: 1-1d, pl. 52: 1-1c (larvae); Forbes, 1923: 668; Bouvier, 1931: 19; Draudt, 1930: 814, pl. 142g; Schuessler, 1936: 218-220; Lemaire, 1976: 47.

Bombyx astynome Olivier, 1790: 43; synonymized: Westwood, 1837: 24; type locality: Carolina and Virginia; fixed by Ferguson, 1971: 80, as Virginia.

Phalaena (Bombyx) perspicellina Martyn, 1797: pl. 30: 88. Type locality unknown. New synonymy.

Dryocampa pellucida, Morris, 1862: 232.

# ADULT

Male (pl. IV, fig. 1): Sexual dimorphism strongly developed. Head, thorax, abdomen brownish wine-red; the abdomen in some specimens with a tendency to be ochreous; legs ochreous; forewings brownish wine-red, hindwings somewhat more on the brownish side; postmedian line not very much accentuated; white discal spot large; underside of wings with an ochreous hue especially on the hindwings; dark scales very small and scarce, some may be detected almost always when examined under magnification; hyaline patch on forewing strongly developed. Outer margin of forewings straight making the wing triangular; of hindwings in most specimens rounded, however, all transitions to absolutely straight ones may be found in one and the same population, e.g., Pine Grove, PA. Length of forewing 18-20 mm (20 specimens measured).

Female (pl. IV, fig. 2): Much larger than male and not very thickly scaled; wings distinctly rounded; terminal area of wings greyish-purple, remainder brownish-ochreous; contrast may be strong between the two areas, however, in many specimens it is only slight; there may be found also some of the wine-red male coloring in some females; postmedian lines well expressed on both wings; white discal spot large; about the dark scales what is said under the male applies also here; underside of wings as upperside; abdomen, head, thorax, legs all ochreous. Length of forewing 24-29 mm (30 specimens measured).

Head: Laterofrontal suture visible; frontal protuberance transverse, not prominent; male antenna with 15 rami; posterior aspect of head showing two well developed lateral processes of the margin.

Legs: Epiphysis in male a little more than half as long as the tibia; rounded dorsally, straight ventrally, ending in a point, covered with very small hairs; in females only occasionally present, much smaller than in male, originating at beginning of second quarter of tibia, extending half way into third quarter, same form as in male. Empodium moderate, consisting of one tubercle with a single small seta. On anterior tibia only one obtuse process instead of the usual apical spines. GENITALIA

Male (fig. 7e): Uncus M-shaped, heavily chitinized; gnathos not broad, triangular shield; lateral margins of valves almost straight; inner margin of valves more uneven than in A. assimilis; apex bifurcate, ventral part a little shorter, strongly chitinized, dorsal part twice as wide; free annellus heart-shaped, with high apices, the cleft strongly chitinized (as in A. consularis); aedoeagus different from all other species, except those of the group, rounded like a boomerang, carina with serrated ridge ventrally; vesica with one elongated spine-like, minutely serrate cornutus spically and in some populations with preapical one reduced to a chitinized plate or spot; proximal end wider in lateral view than in other species of the genus. (Gen. prep. ROM 3-002).

Female (fig. 8f): Very compact looking, especially the antrum; ostium narrow and strongly sclerotized; antrum wedgeformed cephalad; ductus bursae abruptly bent where bursa copulatrix is connected; lobuli vaginales very high; valves of ovipositors of almost uniform width, large and apically rounded. These last three characters diagnostic for the species. Sterigma as usual, perhaps not as wide as in other species. The ductus seminalis is connected almost on the dorsal side of the end of the antrum. Bursa copulatrix more or less rounded and not too large. Signum present in some specimens, in other absent. (Gen. prep. ROM 3-008).

EGG

Orange, more rounded than flat; 1.1 x 1.6 x 0.8 mm.

LARVA (pl. I, fig. 10)

First instar: Body color dark olive; headcapsule and anal plate black; subspiracular faint yellowish line just perceptible; horns on thoracic segment II black ending in two long setae; spiracles black with very indistinct bordering; spines on body not too strongly developed; length 5 mm.

Second instar: Body color light yellowish olive; headcapsule light beige brown; anal plate of body color but paler; horns on thoracic segment II very long and slender, setae much shorter than in first instar; some scattered white granulations; between subdorsal greenish lines a darker dorsal band; spiracular line also greenish; spiracles blackish with body colored border; length 12 mm.

Third instar: Body color greyish olive; headcapsule as before and still lighter; anal plate pale amber; horns on thoracic segment II shorter than before, the setae very reduced; white granulations on body more conspicuous; a very faint dorsal line (no band); subdorsal lines light pinkish; pinkish also a subspiracular band; spiracles black, almost no bordering, between two fine whitish lines; length 20 mm.

Fourth instar: Body color as before; headcapsule greenish; anal plate pale amber; horns on thoracic segment II shorter and thinner, no setae at end; white granulations as before; dorsal line more expressed; between the subdorsal pinkish lines patches slightly darker than the body; spiracles black with whitish bordering; conspicuous subspiracular pinkish band; length 25 mm.

Fifth instar: Body color greyish olive; headcapsule greenish; anal plate dull amber; horns on thoracic segment II almost smooth, clubbed, 6-8 mm long; white granulation not too dense over entire body; dorsal line fine; space between the pink subdorsal lines darkened in patches; the subdorsal lines now wider and more prominent; spiracles black with whitish bordering in a whitish, narrow, wavy band; subspiracular band also wide, pink; all the colors more saturated than in the instar before; length 42-55 mm. it should be noted that all the colors in A. virginiensis are pastel colors not strong colors as in A. pellucida. Headcapsule shown in fig. 5e, suranal plate in fig. 3e.

# PUPA (pl. VII, fig. 8)

Of the same general type as usual in the genus, but more slender posteriorly, the lateral segmental thorns stronger, some double; the bifurcation of the cremaster with an inwardly bent bifurcation.

## DISTRIBUTION

The species is very widely distributed; it ranges from Arkansas through Missouri northward to Minnesota and then east through Wisconsin, Illinois to the eastern seaboard south to Virginia; in Canada it extends from Manitoba eastward through Ontario and Quebec to Nova Scotia.

# TYPE MATERIAL

Type material for the three names: virginiensis, astynome and perspicellina is not known to be preserved anywhere.

As type locality for *virginiensis* Drury names Virginia; as that of *astynome* Olivier gives Carolina and Virginia; Martyn does not mention type localities.

It is well known that the correct identity of the species has been questionable since Drury's (1773) original figure, which is in color but only certain as being a species of Anisota. Smith (1797), Westwood (1837) and Boisduval (1872) variously confused the Drury taxon with A. pellucida and even A. senatoria. Packard (1905) synonymized A. virginiensis and A. pellucida, and Morris (1892) even synonymized A. virginiensis to A. pellucida, making thus the senior synonym the junior one.

To finally solve this problem we are designating herein a neotype for both names: virginiensis and astynome.

With F. H. Rindge we select and designate as neotype for both names of *A. virginiensis* and *A. astynome* a female from Suffolk, Virginia, collected 19 June 1944 by Otto Buchholz. This neotype is in the American Museum of Natural History in New York.

### BIOLOGY AND REMARKS

A. virginiensis is the widest ranging species in the North. The moths fly in June and July mostly. The species is sympatric with A. manitobensis in some areas. The preferred foodplant is Q. rubra.

Papers published which supposedly give the flight times of A. virginiensis (Dominick and Edwards, 1971; Solomon, 1971) actually refer to A. pellucida. However, we believe the flight time for both these species is the same time of day.

There is evidence that A. discolor and A. virginiensis share some characters which are not common to A. pellucida, In the fourth-instar larvae of the first two species the stripes are light pink, while in A. pellucida these stripes are magenta. The ova of A. pellucida are smaller and are mostly brown during embryogenesis, whereas the larger eggs of A. discolor and A. virginiensis go through a red phase before hatching.

# MATERIAL EXAMINED

CANADA. MANITOBA: Morden (CNC); Thornhill (CNC). NOVA SCOTIA: Argyle (USNM); L. Kejimkujik (USNM); see also in the Proceedings of the Nova Scotian Institute of Science, Session of 1952-53 (Vol. XXII, Part 3), p. 209 under no. 846. ONTARIO: Aberdeen (FIS); Acton (CNC); Algonquin Prov. Park (McM); Banks (CNC); Bear I. (CNC); Benny (FIS); Bergland (CNC); Blueberry I. (ROM); Brent (FIS); Capreol (ROM); Chaffeys Locks (ROM); Chalk River (FIS); Grand Bend (CNC); Johns Falls (larva) (ROM); Kenebec I. (FIS); Latchford (FIS); Norman Twp. (ROM); Ottawa (CNC); Petawawa (FIS); Port Rowan (CNC); Rainy River (CNC); Rondeau Prov. Park (ROM); Rosebank (ROM); Sault Ste. Marie (CNC, McM); Severn Falls (FIS); Silver Water (FIS); Simcoe (CNC); St. Thomas (UWO); Sudbury (FIS); Trenton (CNC); Toronto (ROM); Vittoria (CNC); Washago (CNC). QUEBEC: Aylmer (CNC); Calumet (LM); Ft. Coulonge (CNC); Laniel (LM); Meach L. (CNC); Montreal (LM); Norway Bay (CNC); Orleans (LM-Sheppard Coll.); St. Johns (LM); Ste-Anne-de-Belle-vue (LM); Wakefield (CNC). UNITED STATES. ARKANSAS: no other data (AMNH). CONNECTICUT: Putnam (AMNH). ILLINOIS: Lacon (UII); Oregon (city) (UII); Palos Park (UII); Putnam Co. (UII). MAINE: no other data (YPM). MICHIGAN: Agr. College (MSU); George Reserve (MSU); Gull. L. Biol. Station (MSU); L. Orion (MSU); Wakelee (UII). MINNESOTA: no other data (AMNH); Itassa Park (USPM); Ramsey Co. (USPM). MISSOURI: UMo Coll.: Columbia (also larvae); Curryville; Meramec Highlands; Roaring River State Park (larvae); Round Spring State Park (larvae); Vichy; Heitzman Coll. the following Counties: Benton; Bollinger; Boone; Carroll; Crawford; Cole; Jasper; Johnson; Lewis; Maries; Montgomery; Ozark; Randolf; St. Louis; Taney; Texas; Warren; Washington. NEW HAMPSHIRE: no other data (AMNH); Franconia (AMNH). NEW JERSEY: no other data (AMNH); Elizabeth (AMNH); Essex Co. (AMNH); Fort Lee distr. (AMNH); Montclair (AMNH); Morris Co. (AMNH); Newark (AMNH, FMNH); Ocean Co.; Orange Mts. (AMNH); Union Co. (AMNH). NEW YORK: Bear Mts. (AMNH); Bedford (AMNH, FSCA); Bronx (AMNH); Bronx Park (AMNH); Brooklyn (CNC); Buffalo (ROM); Clayton (AMNH); Ithaca (MSU); New York (AMNH). OHIO: Millport (CM); Summitville (UMo). PENNSYLVANIA: Delaware Water Gap (AMNH); Alleghany Co. (CM); Charleroi (CM); Finleyville (CM); Ingomar (CM); Jeannette (CM); Pine Grove (AMNH, LACM, Peigler Coll.); Pittsburgh (CM); Scranton (AMNH). RHODE ISLAND: Elmwood (CM); Rockland (AMNH). TENNES-SEE: Johnson City (AMNH). VIRGINIA: Amherst (CM); Suffolk (AMNH). WISCONSIN: Balsam L. (USPM). Examined 100+ males, 175+ females, dissected 9 males and 11 females.

## SENATORIA GROUP

# Anisota finlaysoni Riotte

Anisota finlaysoni Riotte, 1969: 141; Ferguson, 1971: 76; Lemaire, 1976: 47.

Anisota senatoria (not J. E. Smith, 1797); Forest Lepidoptera of Canada (B. M. McGugan, Co-ordinator), 1958: 48 (partim). [Error of determination.]

ADULT

Male (pl. III, fig. 6): Sexual dimorphism strongly developed. Head, thorax, abdomen, legs, fore- and hindwings normal sepia brown and not too strongly

sprinkled with dark scales in the apical area of forewing; hyaline patch on forewing clear; postmedian line well marked; white discal spot quite large; on the underside of wings a distinctive brass-yellowish suffusion. Outer margin of forewing very slightly concave between M<sub>2</sub> and Cu 1b, of hindwings almost all straight. Length of forewing 17-20 mm (16 specimens measured).

Female (pl. III, fig. 7): Thinly scaled. Unicolorous, pronounced tawny ochreous; only slightly sprinkled with dark scales at apex of forewing; postmedian lines on both wings straight and unconspicuous; white discal spot quite large; a purplish suffusion in the terminal area usually much reduced but in some populations occurring; underside of wings with ochreous-yellow suffusion. Outer margin of both wings rounded, the hindwings more so than the forewings. Length of forewing 24-30 mm (17 specimens measured).

Head: Laterofrontal suture strongly visible. Frontal protuberance transverse, insignificant. Male antenna with 18 rami. Posterior aspect of head showing no lateral projections, only a low convexity on either side, apex rounded.

Legs: Epiphysis in male well developed, broad, longer than two thirds length of tibia, width about half of length; one side rounded, the other straight, apex blunt, covered with very small hairs. In most females epiphysis absent, in others very small but of same form as in male. Empodium formed of two tubercles, the distant one well developed with a long, strong seta, the proximal one very small with a very small and thin seta.

# **GENITALIA**

Male (fig. 7c): Uncus V-shaped, apices strongly sclerotized; gnathos a broadly rounded shield, usually with a pronounced triangular process arising apically; valves perceptibly curved distally; apex bifid, ends of almost equal length, ventral part of the bifurcation sclerotized, dorsal part wider; free annellus a ring tapering off apically. Aedoeagus short, straight, carina bent sharply, blunt, with a row of small serrations; vesica with two conspicuous triangular cornuti, the edge of each serrate; the one at the middle of the vesica with unusual thin, small triangular process dorsally; coecum of the same general form as in the other species. (Gen. prep. ROM 3-004).

Female (fig. 8e): Ovipositor valves rounded at apex; lobuli vaginales high, triangular with more or less pointed apex; ostium bursae a wide funnel-like structure; antrum absent; ductus bursae not sclerotized, short, sharply bent where bursa copulatrix is attached; bursa copulatrix small, round, signum mostly absent or very small; ductus seminalis connected at the very beginning of ductus bursae laterally. (Gen. prep. ROM 3-006).

### EGG

The freshly laid eggs are of a bright yellow color, darkening after some days to a dark reddish brown. Before hatching they turn gray. The eggs are laid preferentially at the apices of the leaves of oak. They hatch after about 15 days and are approximately twice as big as the small eggs of A. senatoria.

# LARVA (pl. I, fig. 5)

First instar: Light yellowish, body not hairy, longitudinally striped with shadowy blackish, faintly pigmented lines: a narrow one at the dorsum and the spiracles, two broader ones in between. The setae are thin and small and the two scoli on the second thoracic segment are only very slightly thicker than all the other ones.

Length of first instar larva: 5 mm.

Second instar: Coloration as in the mature larva: blackish-brown with yellowish stripes: two narrow dorsal ones extending only to abdominal segment 7 inclusive, a straight and somewhat subdorsal line, an undulate supraspiracular one interrupted between the segments, a straight infraspiracular and much interrupted line; the base of the infraspiracular spines, inferior to the infraspiracular stripe, is of the same color. Spiracles black. A light yellowish ventral median stripe. Prongs of the prolegs of the same color. Main difference with all other known larvae of Anisota is the absence of the elongated, thin and slender "horns" on the second thoracic segment. In their place are just two short scoli (1 mm long) which are only very slightly larger than all the remainder. Pronotum heavily chitinized, black with yellowish borders which coincide with the second lateral yellow stripe. Head very dark blackish red-brown, elongated, the frontal plate quite large. Length of second instar larva: 10 mm.

Third to last (fifth) instar: There is no perceptible change between the larva of the second instar and the following ones except for the length. This is a remarkable distinction from the larva of A. senatoria. Length of third instar larva: 21 mm; of fourth instar larva: 32 mm, of fith instar larva: 50 mm. Headcapsule shown in fig. 5c, suranal plate in fig. 3c.

# PUPA (pl. VII, fig. 6)

Blackish brown; spiny and slender; cremaster bifid; the two forks stronger than in A. senatoria and well pointed.

# DISTRIBUTION

Since the original description and the publication of Ferguson (1971) it was found that the distribution of the species corresponds to that of many other moth species in southern Ontario which occur at the north shore of Lake Erie and then again around Belleville and eastward.

## TYPE MATERIAL

Type locality: Shannonville, Hastings County, Ontario. Additional type data: holotype male taken 28 June 1967 sitting at the end of grass stalk at about 1500 hrs; allotype female at the same date and time ovipositing on a white oak tree. Location of types: Royal Ontario Museum, Toronto, Ontario. Paratypes in: AMNH, BMNH, CM, CNC, FIS, FSCA, LACM, MSU, Peigler Coll., RIB, ROM, USNM, UWO, YPM.

### BIOLOGY AND REMARKS

The flight period is from the last third of June to about the middle of July. In the laboratory pupae may fail to diapause.

The main foodplant is white oak. Also chestnut oak (Quercus pini) is found at the type locality and in some instances larvae of A. finlaysoni were found on same. In rearing experiments also other species of oak, especially red oak, were taken, and larvae transferred to red oak trees on the grounds of Queen's University Biology Station at Lake Opinicon, Chaffeys Locks, Ontario, completed their development on these but did not become established. Also the rare Quercus muhlenbergi was accepted in the laboratory as food by the larvae.

L. R. Finlayson (deceased 1965), Research Officer at the Research Institute, Canada Department of Agriculture, Belleville, Ontario, discovered the species in 1946 after a farmer in Shannonville, Ontario, informed the Institute that an

unknown caterpillar defoliated his oak trees. Finlayson collected over the years, especially in 1957, considerable material of all stages of the species which he rightly recognized as new and undescribed. In 1966 finally all specimens accumulated in Belleville were turned over to the Department of Entomology and Invertebrate Zoology of ROM (nobody else being interested in it) where careful study supported Finlayson's suspicions and provided the stimulus for the present review of the genus *Anisota*.

On 28 June 1967 a fieldtrip was made to the original locality in Shannonville where the first observations had been made in 1946. One male and one famale were found. The circumstances were the same as already observed by Finlayson: the male was sitting in the grass, the female was resting on a white oak leaf laying eggs. About 400 eggs were found in three bunches on three white oak trees, in addition to the eggs of the ovipositing female. All eggs were reared and material of all stages was preserved. A few adults emerged from the pupa only a short time after pupating, in September 1967 which was an especially warm month, and the same happened again in 1968.

Inspection in 1978 by both authors revealed the colony in Shannonville to be still strong.

The species has been reared in southern France from Shannonville eggs by C. Lemaire. Many larvae were dead in the first instar on the European Quercus pubescens which was easily accepted in the last instar. However, successful rearing was accomplished in five weeks on Castanea vulgaris. This is interesting and may perhaps give a clue to the sporadic distribution of the species if it should have originally preferred Castanea sp. and would after the great chestnut blight not have been able to adjust so easily everywhere to oak.

The species apparently is sympatric or nearly so with A. senatoria in some areas of Ontario. Elucidation of these ranges would be a worthwhile undertaking for some local lepidopterist in the area. We believe that our records for A. senatoria and A. finlaysoni are free from confusion because the determinations are generally based on larvae or dissected adults.

### MATERIAL EXAMINED

CANADA. ONTARIO: Ameliabourgh Twp. (FIS); Barriefield (FIS); Belleville (CNC, FIS, ROM, UWO); Campbellford (FIS); Campbellville (FIS, ROM); Chippewa (CNC); Deseronto (CNC, ROM); Erinsville (FIS); Frankford (FIS); Glen Miller (FIS); Hagersville (ROM); Kingston (ROM); Lindsay (FIS); Mountain View (CNC); Napanee (CNC, ROM); Odessa (CNC, UWO); Otter Lake (ROM); Palermo (FIS); Rockton (ROM); St. Williams (ROM); Sheffield (CNC, ROM); Shannonville (CNC, ROM); Snyder (CNC, ROM); Thurlow (FIS); Tweed (FIS); Tyendinaga (FIS). UNITED STATES. MINNESOTA: no other data (AMNH); Green Lake (UCal); Minneapolis (FMNH); Olmstedt Co. (USPM). WISCONSIN: Lake Delton (Sieker Coll.); Chippewa Co. (CalAcSci). Examined long series of males and females, dissected 22 males and 15 females.

# Anisota peigleri Riotte

Anisota peigleri Riotte, 1975: 105; Lemaire, 1976: 47.

### ADULT

Male (pl. III, fig. 1): Abdomen, fore- and hindwings above strongly mahoganybrown; head, legs, fore- and hindwings beneath ochreous except for an apical purplish-gray marginal space; forewings above sprinkled with dark scales especially apically; beneath dark scales especially on hindwings; postmedian line easily perceptible on upper forewing and on all wings beneath; hyaline patch on forewings present but much covered with thin scales; white discal spot large. Outer margin as in A. finlaysoni, i.e. with forewing slightly concave between M2 and Cu 1b, with hindwing perceptibly concave. Length of forewing 19-20 mm (12 specimens measured).

Female (pl. III, figs. 2, 3): Unicolorous lighter and of a clay brown with some orange hue, except for the marginal area of the forewings which shws on both sides slight purplish-gray hue, in some specimens (ex-larva, Clayton, Georgia) this purplish strongly expressed over entire wing surface; most specimens with strong sprinkling of somewhat clustered dark scales on both sides of the wings; some specimens with only a very few scales; white discal spot large. Outer margin of both wings slightly rounded. Length of forewing 25-32 mm (11 specimens measured).

Head: Unique sexual dimorphism in certain important characters: laterofrontal suture visible in male but obscurred in female; frontal protuberance slightly protruding in male but reduced in female. Male antennae with 12 rami. Posterior aspect of head ellipsoid, outline smooth without lateral projections.

Legs: Epiphysis slightly shorter than tibia, bulged unilaterally, densely covered with very fine, short hairs, observed in the male. Empodium very small with a short, weak seta.

## **GENITALIA**

Male (fig. 7b): Uncus M-shaped, apices strongly sclerotized; gnathos similar to A. finlaysoni, i.e. reduction in width from and even narrowing into a sudden narrowness finally ending in a blunt end; in single specimens the apex of the gnathos is lip-formed; valves narrow; apex bifid, ends of unequal length, ventral part of bifurcation strongly sclerotized, dorsal part wider; free anellus a well-formed crescent. Aedoeagus long, straight, carina bent sharply, apex like a goose head with many little teeth on top of "head", still more than in A. finlaysoni; the proximal end tripartite; dorsally only very slightly chitinized; vesica with a well-developed cornutus on apex, while the preapical one may be present or absent.

Female (fig. 9b): Ovipositor valves rounded at apex, oblong, strong, large; lobuli vaginales not too high; ostium bursae wide; antrum absent; ductus bursae unsclerotized not very long; sharply bent where bursa copulatrix is attached as in A. finlaysoni; bursa copulatrix short and oblong; no signum observed; ductus seminalis connecting at beginning of ductus bursae.

# EGG

Yellow;  $1 \times 1 \times 0.8$  mm. Turning reddish brown and then gray as development of embryo proceeds.

# LARVA (pl. I, fig. 6)

First instar: Body color, anal plate included, ivory; headcapsule black; dorsal line thin, grayish-olive; horns on thoracic segment II long, bifurcate; on thoracic segment III shorter hornlike outgrowth, bifurcate, on a thicker base; spines all over body; long subspiracular bristles in horizontal row; on abdominal segment 9 bifurcate bristles on a slightly larger base.

Second instar: Body color yellowish; anal plate brownish-black; thin dorsal line grayish-olive and pale; a subdorsal and lateral stripe of same color about three times

the width as the dorsal one; also a spiracular line and subspiracular rounded scoli on each segment. In some cases the line on dorsum and the stripes are dark blackisholive. On both stripes and subspiracular region of each segment is a triangular horn; on the subdorsal stripes is also a smaller horn latero-caudally from the larger one. Thoracic horns only slightly bifurcate. Spiracles black. On segment anterior to anal plate is a dorsal larger horn on a base. Small blackish spots irregularly all over body.

Third instar: Body color jet-black just after molting, later becoming more olive-gray. Dorsal line black; broken whitish-yellow weak subdorsal lines; slightly thicker lateral ones of the same type. Spiracular area yellow as in previous instar. Thoracic horns long and only slightly bifurcate. On abdominal segment 11 and anal segment are single strong dorsal bifurcate spines and two smaller lateral ones, no spiracular spines. Anal plate black.

Fourth instar: Body color jet-black just after molting, some days later changing to olive-gray. Very spiny. Three yellowish broken lines on each side; subdorsally very faint broken line, absent in some cases. Horns long, clubbed with very fine bifurcate setae apically. The spiracular line is unbroken and the subspiracular scoli surrounded by yellow patches. All lines pale yellow, tending to whitish washed-out color. Caudal spines as in previous instar. larvae very shiny in this and previous instars (as in all species in the genus).

Fifth instar: Larvae now velvety jet-black; when viewed at certain angles a trace of olive-gray color perceptible. Very spiny; much more so than in larvae of A. finlaysoni and A. senatoria (consult pl. V). Subdorsal yellow lines often almost absent or only slightly visible as disjunct dashes; lateral lines also broken, sometimes only remnants visible; supraspiracular line intermittent; subspiracular line wavy and thicker; a round yellow patch surrounding the spiracle on thoracic segment II. On abdomen a narrow yellow line from second abdominal segment to posterior end, sometimes broken, this line much less evident than in A. senatoria and A. finlaysoni.

The chaetotaxis of the thoracic legs differs from that of both A. senatoria and A. finlaysoni.

PUPA (pl. VII, fig. 5)

Medium spiny; chestnut brown; cremaster bifurcate with lateral ecrescences, the latter apparently an important species-specific character (which also occurs in *Dryocampa*).

# DISTRIBUTION

Anisota peigleri maintains high populations every year in upper South Carolina and adjacent areas of North Carolina and Georgia. The following South Carolina counties cover the area where the species appears to be most abundant: Anderson, Oconee, Pickens, Greenville; in outlying areas it becomes rarer and still further away (Florida and coastal South Carolina) it is difficult to find most years. The species may ultimately be found in eastern Tennessee, northern Alabama, and western Virginia, although A. senatoria may also occur in these areas. The distributional pattern is generally characterized by moderate elevations, being uncommon in higher mountains but common in Piedmont, with occasional populations encountered in coastal areas. The populations reported by Beal (1952) under the name A. senatoria possibly refer to the present species.

### TYPE MATERIAL

Type locality: Clemson, Pickens County, South Carolina. Additional type data: holotype male taken 5 August 1974 at light by R. S. Peigler; allotype female taken at same locality 11 July 1974 at light by R. S. Peigler. Location of types: Royal Ontario Museum, Toronto, Ontario. Paratypes: one male and four females in ROM, one female each in AMNH, Lemaire Coll., Peigler Coll., all collected at the same locality during the same summer by the same collector.

### BIOLOGY AND REMARKS

The larvae of this species are very abundant during September and October in the counties of South Carolina mentioned above under "Distribution". Usually a few lower branches are defoliated on medium-sized trees, but it is not unusual to see isolated small or medium trees completely defoliated. Non-native oaks such as Q. palustris planted in yards and parks are especially attacked. In Greenville County the larvae have been found on Q. rubra and Q. marilandica; in the Clemson area they occur on Q. velutina; in all these areas of upper South Carolina the favorites are however Q. nigra and Q. falcata. Larvae collected near Clayton, Georgia and seen in Asheville, North Carolina by the junior author were all on Q. velutina.

The junior author and other entomologists at Clemson University (see Clemson Univ. Coop. Ext. Serv., 1968) always assumed this near-pest to be A. senatoria. A brood of larvae which the senior author reared in Canada from eggs of the allotype, quickly demonstrated to him that two species were involved since he was familiar with larvae of A. senatoria. Once this fact became clear, all of the other differences in the immature and adult stages between the two species were readily found.

Larvae of A. peigleri are variable in the amount of orange striping, as in A. senatoria, but these stripes are more often broken and reduced in the former species. The amount of orange stripes present in A. peigleri appears consistent within colonies, i.e. sibling larvae resemble each other closely. The spines are longer in A. peigleri, and this trait is easily seen when a direct comparison is made of mature larvae of both species. In the adults, the outer edges of the right and left wings diverge more in A. peigleri, whereas they are closer to being parallel in A. senatoria. The forewings thus appear more produced in A. peigleri. Although the examples we figure do not show it, the white dot in the forewing of both sexes tends to be larger in A. peigleri. Other differences between these two species, including genitalic ones, are given in the formal descriptions of the two species. Narrower wings and more yellowish on the underside distinguishes the females of A. peigleri from those of A. stigma.

### MATERIAL EXAMINED

UNITED STATES. FLORIDA: Pensacola (LACM); Gainesville (State Agric. Dept., Honolulu); Interstate-75 Florida Welcome Center (ROM); "Carolina, N. Amerika" (AMNH). GEORGIA: Athens (UGA); Atlanta (Lemaire Coll.); Clayton (LACM, Peigler Coll., ROM). NORTH CAROLINA: Asheville (LACM); Hendersonville (larval parasites with host remains (Peigler Coll., USNM). SOUTH CAROLINA: Clemson (AMNH, FSCA, LACM, Lemaire Coll., Peigler Coll., USNM); Anderson (CNC); Pickens (BMNH); Six Mile (ROM); Seneca (Peigler Coll.); Florence (CLU, Peigler Coll., UGA); Greenville (AMNH, BPBM, LACM, ROM, Peigler Coll., Lemaire Coll.); Westminster (AMNH, ROM); Moncks Corner (ROM). Examined 25+ males and 38 females, dissected 9 males and 8 females.

# Anisota senatoria (J. E. Smith)

Phalaena senatoria J. E. Smith, 1797: 113, pl. 57.

Anisota senatoria; Huebner, 1818-1822: 193; Grote, 1864: 93; Packard, 1864: 384; Kirkby, 1892: 739; Neumoegen and Dyar, 1894: 147; Beutenmueller, 1898: 439, pl. 20: 3; Packard, 1905: 107-111, pl. 20: 10-12; Holland, 1915: 94; Forbes, 1923: 668; Bouvier, 1931' 22; Schuessler, 1936: 213-215; Draudt, 1930: 813; Ferguson, 1971: 73; Lemaire, 1976: 47.

Dryocampa senatoria; Harris, 1835: 72, 592; 1841: 292; 1862: 405, fig. 200; Walker, 1855: 1496; Fitch, 1859: 43; Morris, 1862: 231.

Adelocephala senatoria; Boisduval, 1872: 87.

### ADULT

Male (pl. III, fig. 4): Sexual dimorphism strongly developed. Abdomen, thorax, fore- and hindwings above from dark brown in the south to lighter brown in the north with slight reddish hue, more expressed in the north; head, legs, fore- and hindwings beneath dark orange-ochreous except for an apical dark purplish-grey marginal space in forewings above sprinkled with dark scales especially apically; beneath dark scales more pronounced; postmedian line strongly perceptible on upper forewing and on all wings beneath; hyaline patch on forewings somewhat suffused with thin scales; white discal spot not very large. Outer margin as in A. finlaysoni, i.e., of forewing slightly concave between M2 and Cu 1b, of hindwing almost all straight. Length of forewing 15-19 mm (39 specimens measured).

Female (p. III, fig. 5): Abdomen, thorax, head, legs, fore- and hindwings above and beneath from normally scaled brownish-yellowish ochreous with some orange in the south to lighter yellowish ochreous and thinner scaling in the north also in apparent cline, a more or less pronounced purplish suffusion in the terminal area; postmedian lines on both wings and on both sides in southern specimens strongly marked, in northern ones much weaker; white discal spot not very large; the sprinkling with dark scales may be heavy in the south and nearly absent in the north, it occurs on both sides of the wings; on the underside of the forewings apically a more or less pronounced purplish-grey marginal space. Outer margin of all wings evenly rounded. Length of forewing 26-30 mm (47 specimens measured).

Head: Laterofrontal suture slightly obscured; frontal protuberance well developed and protruding. Male antenna with 15 rami. Posterior aspect of head with scalloped margin and perceptible but rounded processes.

Legs: Epiphysiss in male very small, only 3/5 of length of tibia; not observed in female. Empodium very small with a tiny thin seta.

### **GENITALIA**

Male (fig. 7a): Uncus M-shaped with heavily sclerotized apices; gnathos a triangular roadly rounded shield; valves slightly rounded, apex bifid, both ends almost of equal length, ventral part of the bifurcation strongly sclerotized, dorsal part much broader; free annellus a ring of uniform width; aedoeagus straight and short, carina bent ventrally, strongly sclerotized, proximal to apex a low comb with a few small thorns, apex itself blunt; vesica with cornuti, one small one at half-way and the other at the end spatulate with small thorns; proximal end of aedoeagus almost straight. (Gen. prep. ROM 3-001).

Female (fig. 8d): Ovipositor valves of medium size and rounded at apex; lobuli vaginales low; sterigma also low not prominent, but sclerotization more or less

heavy; ostium bursae not too wide, no antrum; ductus bursae not sclerotized at all, straight, slender; bursa copulatrix elongate, signum absent; ductus seminalis attached in upper fourth of ductus bursae laterally. (Gen. prep. ROM 3-009).

### EGG

Yellow. Eggs from Monroe, MI, 1 x 1 x 0.5 mm; from Connecticut 1.3 x 1.2 x 0.9 mm.

# LARVA (pl. I, fig. 4)

First instar: Body color greenish-yellow; headcapsule black; anal plate not pigmented; thoracic horns on segment II long, smooth, clavate, with two terminal setae of equal length; thoracic legs dark colored; abdominal prolegs of body color; no lines perceptible; length 4 mm.

Second instar: Body color dark greenish, shiny; headcapsule, anal plate and anal legs jet black; yellowish green lines are now perceptible: a dark dorsal line; pale yellowish green subdorsal lines; a wider supraspiracular line of the same coloring, separated by a very narrow dark green line from a broad spiracular one and a row of conspicuous black tubercles; horns on segment I large, finely spinulated, less bifurcate than in the first instar; thoracic legs black, abdominal prolegs dark green, anal legs black; length 10 mm; in the southern populations up to 18 mm.

Third instar: Body color dark yellowish green to olive green; headcapsule and anal plate black; two narrow yellowish dorsal lines; yellowish subdorsal and supraspiracular lines; the spiracular line more narrow; spiracles black with yellowish border; horns on thoracic segment II black, long; length 15 mm; in the southern populations up to 23 mm.

Fourth instar: Body color now black; headcapsule and anal plate black; two dorsal yellow (or orange—depending on the population) lines; the subdorsal line very outspoken, not interrupted at the joints; the supraspiracular line wavy but not broken; the subspiracular line irregular and broken; on each segment a yellow (or orange) ornamentation below the subspiracular line on the body segment; the supraspiracular line is extended on both sides of the anal plate; horns on thoracic segment II longer and stronger than before; length 20 mm; in the southern populations up to 34 mm.

Fifth instar: Body color blackish brown; headcapsule and anal plate black; lines deep yellow ochreous or orange—depending on the population—two dorsal lines (unbroken); a subdorsal straight one (unbroken); a supraspiracular undulating one; a subspiracular one is broken by black intermittances and is bearing the subspiracular row of spines; all spines rather short (as in A. finlaysoni); same subspiracular ornamentation as before; ventrally a yellow ochreous stripe; spiracles black with yellowish border; horns on thoracic segment II as before (4 mm long, thin); all legs and prolegs black; length 35 mm; in southern populations up to 40 mm.

# PUPA (pl. VII, fig. 4)

Spiny and not perceptibly broadened posteriorly. The cremaster bifid, the forks being slightly turned outwards, sharp and not too long.

#### DISTRIBUTION

From the Gulf states, especially Texas and Louisiana (also Mississippi according to Ferguson, 1971: 74), northwards to the Great Lakes, hence through the southwesternmost part of Ontario to the eastern seaboard and then south to the Carolinas and sporadically into Florida. The specimens mentioned by Packard,

1905, from Maine may well constitute the northern limit while the specimens mentioned from Quebec by Winn, 1912, were found to be misidentified A. virginiensis.

## TYPE MATERIAL

With the discovery of A. peigleri it seemed necessary to tie the name A. senatoria to a neotype. We have selected a specimen from a southern state although none from Georgia was available.

We herein designate as neotype of A. senatoria the following male (pl. III, fig. 4): Gibsland, Bienville Parish, Louisiana, 21 August 1976, leg. R. Peigler. Additional type data: specimen collected at light at a rest area on Interstate 20. Other males and females collected with this neotype are deposited in several museums. Location of neotype: American Museum of Natural History, New York.

# BIOLOGY AND REMARKS

We agree with Ferguson (1971) that Abbot's plate leaves no doubt as to the identity of this species. We do not, however, choose to restrict the type locality to Screven or Bulloch counties in Georgia as Ferguson (1971) assumed for both A. senatoria and A. pellucida in his text discussion.

Regarding the diagrammatic aspects of Abbot's plates see also for fuller discussion the above chapter. Larval and adult differences between A. senatoria and A. peigleri are enumerated under the latter species. Additional observations convince us that Abbot figured what we now call A. senatoria rather than what we call A. peigleri. If the "assumed" type locality of coastal Georgia be accepted, it is significant that the junior author failed to find A. peigleri in this area during three years of collecting Anisota there. The data supporting that A. peigleri and A. consularis share the same flight times imply that the two species could not coexist, and the latter occurs there.

As pointed out by Kimball (1965) and Ferguson (1971), this species is rare in the Southeast. In eastern Texas, northern Louisiana up through Missouri the species is very common and attains pest status (see Ignoffo et al., 1973). This species is much commoner in Walker Co., Texas, than either A. fuscosa or A. discolor but becomes rarer westward; we have a record from Bastrop from R. O. Kendall. The insect is also abundant (although only periodically) in New England where Hitchcock (1958, 1961 a,b,c) carried out some excellent observations. We refer the interested lepidopterists to his papers. Additional literature on the pest status include Clarkson (1883), Claypole (1883), Fitch (1859) and Missouri Forest Pest Report (1973).

Specimens from Texas and Louisiana appear darker than those from the Northeast, although we find no larval differences. Benjamin D. Williams III reports, in litt., that he has attracted males to "calling" females early afternoon, during the two hours following noon. He reports Q. palustris as a host record. In the southern populations it is possible that males fly later in the day since several were collected at light and the forewings are less transparent. Additional material and data from central states are needed.

There is an old specimen labelled "Mexico" in the Lemaire collection from the Hans Fruhstorfer collection which Lemaire kindly verified by dissection. Given what is said about "Mexico sensu lato" under A. leucostygma this specimen may well be one of the numerous Texas ones.

# MATERIAL EXAMINED

ONATRIO: Ailsa Craig (FIS); Arner (CNC); Breslau (FIS); Dereham (ROM); Frome (CNC); Grand Bend (CNC); Kingsville (FIS); Ojibway (44 larvae and 100 pupae ex 1947, original Finlayson research) (ROM); Poplar Hill (FIS); Ranelagh (ROM); Wallenstein (CNC); Winona (FIS); Yarmouth Centre ARKANSAS: Crawford Co. (larvae) (UArk); Hope (CNC). UNITED STATES. (AMNH). FLORIDA: no other (LM). CONNECTICUT: Mansfield (AMNH); Archbold Biol. Station, L. Placid (AMNH); Monticello (MCZ). DELA-WARE: Delaware City (CM); New Castle Co. (AMNH). ILLINOIS: Algonquin (UII); Palos Park (UII). INDIANA: Hessville (FMNH); Knox (AMNH, FMNH, YPM); N. Judson (UII). IOWA: Decorah (AMNH). LOUISIANA: Dry Creek (larvae) (LSU); Gibsland (AMNH, BPBM, LACM, Lemaire Coll., Peigler Coll., ROM, USNM). MASSACHUSETTS: Chatham (MCZ); Martha's Vineyard (AMNH, LM, YPM). MICHIGAN: Agric. College (MSU); Joseph Co. (MSU); Monroe (and larvae) (ROM); Ramona (LACM); Wayne Co. (MSU), MINNESOTA: no other data (AMNH); Hennepin Co. (USPM); Long Prairie (LACM); St. A. P. (USPM). MISSOURI: Bagnell (LACM, Sieker Coll., YPM); Phelps Co. (larvae) (UMo); Pike Co. (Heitzman, in litt.); Stone Co. (larvae) (UMo); Texas Co. (larvae) (Peigler Coll., ROM). NEW JERSEY: no other data (MJCZ); Bay Head (MJCZ); Clementon (ROM); Cranford (AMNH); Elizabeth (FMNH); Jamesbourgh (AMNH); Lakehurst (AMNH); Morris Co. (AMNH); Newark (AMNH, CM); Paterson (AMNH). NEW YORK: Albany (AMNH); Brooklyn (CNC); Buffalo (CM, ROM); Long Island (AMNH); New Windsor (CalAcSci); New York (AMNH, CM, CalAcSci, LM); West Farms (CM). NORTH CAROLINA: Southern Pines (LM); Sylva, Jackson Co. (FMNH). OHIO: Anna (LACM); Millport (CM, ROM, UMo); Summitville (CM, ROM, UMo). PENNSYLVANIA: no other data (CalAcSci); Alleghany Co. (CM); Delaware Water Gap (AMNH); Lititz (FMNH); Pittsburgh (CM); Rock Hill Furnace (CM); Rockpoint (CM); Scranton (AMNH). RHODE ISLAND: no other data (MCZ); Glenwood (CM); West Kingston (AMNH); Providence (CM). SOUTH CAROLINA: no other data (CIU); Greenville (larvae) (Peigler Coll.). TENNESSEE: Burrville (FMNH); McKenzie (CM). TEXAS: Bastrop Co. (Kendall Coll., ROM); College Station (Peigler Coll., ROM); Jasper (larvae) (ROM); Marshall (LACM); Nacogdoches (AMNH); San Jacinto Co. (ROM); Stubblefield L., Walker Co. (AMNH, BPBM (and larvae), LACM, Lemaire Coll., ROM). VIRGINIA: Kauhana (MCZ). WISCONSIN: Wausau (LACM). Examined 114 + males, 114 + females, dissected 16 males and 12 females.

# STIGMA GROUP

### Anisota consularis Dyar

Anisota consularis Dyar, 1896: 166; Packard, 1905: 106-107, pl. V: 8; Bouvier, 1931: 23; Draudt, 1930: 814; Kimball, 1965: 69, pl. III: 23-25; Ferguson, 1971: 72; Lemaire, 1976: 47.

Anisota stigma (not Fabricius, 1775); Ferguson, 1971: 67,72.

## ADULT

Male (pl. II, fig. 5): Sexual dimorphism strongly developed. Head, Thorax, abdomen, legs, fore- and hindwings dark sepia-brown and strongly sprinkled with dark scales, even on underside; hyaline patch on forewing very thinly covered with scales; postmedian line well perceptible, especially on hindwing; white discal spot

well-developed; on underside of wings orange tinge. Outer margin of both wings almost straight. Length of forewing 19-21 mm (21 specimens measured).

Female (pl. II, fig. 6): Head, thorax, abdomen, legs ochreous brown; forewings raw sienna to rosy brown (quite variable); hindwings darker and usually with a rosy tinge; all wings strongly sprinkled with dark scales; postmedian lines weak but sometimes well expressed; white discal spot quite reduced. Outer margin of both wings strongly convex. Length of forewing 26-30 mm (19 specimens measured).

Head: Laterofrontal suture slightly obscured. Frontal protuberance perceptibly protruding. Male antenna with 18 rami. Posterior aspect of head distinctly rounded at apex, processes slightly rounded.

Legs: Epiphysis observed only in males; % of length of tibia; very convex dorsally midway along its length; straight ventrally; ending in narrow point; covered with short bristles; bearing on the ventral margin somewhat longer ones. Empodium one thin tubercle with one medium-sized seta.

## **GENITALIA**

Male (fig. 6c): Uncus narrowly M-shaped, apices chitinized in a very peculiar way, the sclerotization forming a ridge of variable intensity; lateral borders of gnathos sinuate, apically forming a triangular rounded projection; valves basally and laterally very straight; parts of bifurcation of almost equal length, the dorsal part twice as wide as the ventral part; free annellus heart-shaped, strongly chitinized in cleft between the low apices. Aedoeagus very short, carina bent, straight, its apex with a row of small teeth; vesica very narrow with two small similar cornuti, the apical one with a few small teeth; proximal end not as sharply outlined as in the other species. (Gen. prep. ROM 3-030).

Female (fig. 8b): Ovipositor valves large, elongate; lobuli vaginales low; sterigma of medium breadth, not as much lipformed as in the other species; ostium bursae quite narrow; ductus bursae somewhat bottle-shaped, narrowing towards bursa copulatrix which is conspicuously oval and in the specimens inspected had a signum in the form of a round plate with concentric circles of chitinization; ductus seminalis attached laterally just after the beginning of ductus bursae. (Gen. prep. ROM 3-031).

EGG

Yellowish, 1 x 1.1 x 0.6 mm.

LARVA (pl. I. fig. 3)

First instar: Body color pale yellowish with a slight greenish tinge; headcapsule jet black; anal plate of body color; fine dorsal line olive; subdorsal line same color, twice as thick as dorsal one; spiracular line same color, waved, interrupted at segments; long spines on each segment subdorsally, on a thick conelike base, black; long horns on thoracic segment II bifurcate; short horns on thoracic segment III bifurcate; length 3 mm.

Second instar: Body color as in first instar, however, some larvae tending to a more dark coloring; headcapsule light brown; anal plate also; dorsal line narrow olive-black; subdorsal lines same color washed out, much wider; a washed out olive supraspiracular line bordered by a whitish line on each side; an olive black spiracular line with light bordering; spines now short; also horns on thoracic segment II only of normal length, bifurcate; short, bifurcate horns also on thoracic segment III; length 4.5 mm.

Third to fith instars: Body color fleshy to red-brown; headcapsule reddish-beige-brown; anal plate of body color, however, in flesh colored larvae both, headcapsule and anal plate are with all the feet red-brown; dorsal, subdorsal, supraspiracular and spiracular lines olive-blackish with the tendency to the black; often all lines bordered by a whitish space so that entire larva looks much more white than colored because of many round white spherish ecrescenses all over the body; larvae with only few white ecrescenses show the body color between the lines; spines very strongly expressed; spiracles blackish with whitish border; thoracic horns on segment II clubbed, 10 mm long; short scoli on segment III bifurcate; on segments 8 and 9 longer scoli, on segment 9 only one in the middle; length in third instar 10 mm; in fourth instar 25 mm; in fifth instar 32 mm. Headcapsule shown in fig. 4c, suranal plate in fig. 2c.

## PUPA (pl. VII, fig. 2)

Compared with pupae of the other species of *Anisota* quite slender and of even width; not very spiny; cremaster short and compact; bifurcation straight outwards, very pointed; color lighter brown.

#### DISTRIBUTION

Although previously only known from widespread records in Florida, the junior author collected the species in Long and Bulloch counties of coastal Georgia. The latter area is very close to the state line of South Carolina so that one might expect the species in that state (but only near the coast) but it was not found in northern Charleston County after many years of intensive collecting there by the late R. B. Dominick. The moth might also be found eventually in other states on the Gulf Coast. The range is evidently limited by an ecological need for a mild climate.

#### TYPE MATERIAL

Type-locality: West Palm Beach, Florida. Additional type data: reared from larvae found in January 1896 on live oak. Location of types: United States National Museum, Washington, DC; the male type designated by Ferguson (1971) as lectotype, August 1896; the female type 15 September 1896. Types were examined by the junior author.

#### BIOLOGY AND REMARKS

It is apparent unfortunately that no previous author has had a clear understanding of the species, including Ferguson (1971) who questioned the color figures in Kimball (1965, pl. 3, figs. 23, 24 and 25). These do indeed represent A. consularis, as the senior author verified these specimens (in FSCA) by dissection. Férguson's figures for this species (1971, pl. 5, figs. 16, 17 and 18) are correct, but his figure 5 on the same plate is also A. consularis, not A. stigma. This latter female was verified (in USNM) by the junior author. Ferguson (1971: 72) also questioned the correct identification of the figure in Draudt (1930, pl. 142f), saying it "is an obvious stigma". This may be true or the figure is just as likely correct, especially if one considers the artist may have "corrected" the transparent forewings with the belief these had been rubbed.

Although it is now abundantly clear that Ferguson's "Floridian stigma" is actually A. consularis, he was correct in seeing the relationship of it to the Texan A. fuscosa. In these two species there is ground color variation from light beige to rust to light orange to purplish brown in both sexes, while specimens of A. stigma are almost always rusty colored.

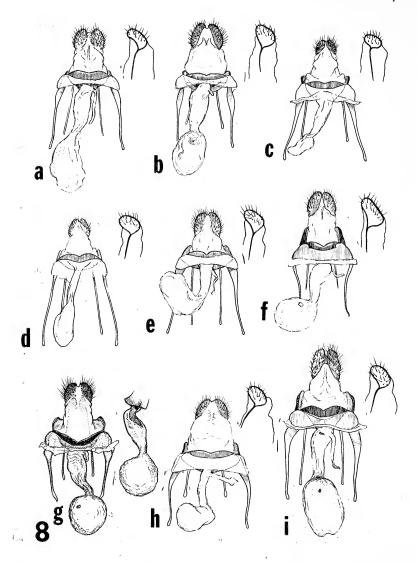


Fig. 8. Female genitalia, with lateral view of ovipositor alongside: a. A. stigma, b. A. consularis, c. A. manitobensis, d. A. senatoria, e. A. finlaysoni, f. A. virginiensis, g. A. leucostygma, h. A. oslari, i. A. assimilis.

The mature larvae can be greenish cream, or brownish, or pink fleshcolored, the latter color form with a black and white lateral stripe on each side. The pink form was figured by Packard (1905, pl. 5, fig. 8). All the larvae within a brood may be one of these color forms, or such may not be the case. This explains a remark in Packard

(1905: 107) about larvae of A. consularis being found "in company with those of A. stigma", in an area far south of the known range of the latter species. These color variations occur in mature larvae of A. stigma and A. fuscosa also.

Until now, the only reported host was live oak, *Quercus virginiana* (Dyar, 1896; Packard, 1905; Ferguson, 1971). The junior author collected larvae in Bulloch Co., Georgia, on *Q. nigra* and *Q. falcata* and also on these two trees in central Florida. D. Baggett collected them in Duval Co., Florida, in dry sandy areas on *Q. laevis* and *Q. myrtifolia*.

In Georgia the species flies in late July through early August judging from larval finds. In Florida records are mainly July through September depending on latitude but we believe the species is strictly univoltine.

The relatively high ratio of females over males in collections leaves no doubt that males are day-fliers. Reared females emitted pheromone in upper South Carolina at the flight time of A. peigleri. Since these two species are entirely alloptaric, having the same flight times poses no problem of hybridization in nature. This presumed flight time is additionally supported by the only partially developed transparentness of the forewings in the males.

#### MATERIAL EXAMINED

UNITED STATES. FLORIDA: no other data (AMNH); Cassadega (CNC, FSCA, Hilton Coll.); Crystal River (LACM); Gainesville (FSCA); Jacksonville (AMNH, LACM); Lake City (USNM); Largo (CNC); Lutz (AMNH, CM, ROM); Martin in Marion Co. (ROM); Miami (AMNH, CM); Palm Beach Co. (USNM); St. Johns Co. (ROM); Stemper (CM); Stuart (USNM); Summer Haven (CM); Suwanee Springs (Lemaire Coll., Peigler Coll.). GEORGIA: Long Co. (larva) (ROM); Statesboro, Bulloch Co. (AMNH, LACM, Lemaire Coll., Peigler Coll., ROM). Examined 40 males, 22 females, dissected 3 males, 3 females.

#### Anisota fuscosa Ferguson New Status

Anisota stigma fuscosa Ferguson, 1971: 70; Lemaire, 1976: 47.

#### ADULT

Male (pl. II, fig. 3): Sexual dimorphism not marked in this species. Head, thorax, legs, abdomen, fore- and hindwings almost unicolorous reddish brown, only terminal area of forewings with a mostly only slight purplish hue, the basal area without such hue. Forewings sprinkled with dark scales in varying density; hindwings not or only with very few dark scales in terminal area. No hyaline patch on forewing; postmedian line on both wings blackish-purplish, not strongly developed; antemedian line only slightly expressed or even absent; white discal spot prominent; middle field not contrasting (as it is in A. stigma). Outer margin of somewhat pointedly triangular forewings more straightened than rounded; of hindwings rounded. On the underside the unicolorous reddish brown is overlaid with some ochreous orange; terminal areas wholly or at least apically with purplish hue; only postmedian lines expressed. Length of forewing 20-21 mm (10 specimens measured).

Female (pl. II, fig. 4): Head, thorax, legs, abdomen, fore- and hindwings unicolorous clay brown with very slight purplish hue in terminal area. Forewing strongly sprinkled with dark scales; hindwings only slightly developed; antemedian line very slight; white discal spot small. Outer margin of wings as in male. On the underside unicolorous clay brown, dark scales massed apically on forewings and over entire surface of hindwing. Length of forewing 32 mm (4 specimens measured).

Head: Laterofrontal suture very much obscured; frontal protuberance very perceptibly protruding; male antennae with 16 rami; posterior aspect of head triangular with flat simple or double rounding on each side between base and tip.

Legs: Epiphysis of ¾ length of tibia; ventrally slightly rounded; dorsally highly rounded in middle; ending in blunt point; covered with fine bristles, ventrally with somewhat longer fine hairs. Empodium one tubercle with one strong, not too short seta.

#### **GENITALIA**

Male (fig. 6b): Overall impression square; uncus a strong, broad W; gnathos evenly proceeding triangular shield, somewhat pointed; longer than in A. stigma; valves rounded, apex bifid, dorsal bifurcation not much longer than ventral one which is strongly sclerotized; free annellus a low crescent of even height; aedoeagus short; carina rounded at apex, strongly sclerotized, with a comb of not too prominent little teeth, not too large, pointed and thorned cornutus apically and a preapical one which may be a sharp thorn (as in A. consularis) or just a very slightly sclerotized spot or anything in between, this being observed only in A. fuscosa. (Gen. prep. ROM 3-159).

Female (fig. 9a): Ovipositor valves large and round apically; the basic part conspicuousy long, longer than in any other investigated species of Anisota; lobuli vaginales strong; antrum strong developed, almost as in the A. virginiensis group with chitinized wedge-form into ductus bursae; ductus bursae twice twisted, first time after antrum making sharp left turn; then where bursa copulatrix attaches turning to the right; ductus brusae a wide and strong "hose"; bursa copulatrix quite elongated with a small round chitinized mark as signum; bursa and ductus showing a narrow network of fine lines. (Gen. prep. ROM 3-160).

EGG

Light yellow, round; size approximately like that of A. stigma.

LARVA (pl. I, fig. 2)

First instar: Body color ivory; headcapsule brown; anal plate brown; thoracic legs brown; no dorsal line; horns on thoracic segment II brown, bifurcate with thin seta on each end; 2 rows of subdorsal brown scoli with seta; supra- and subspiracular scoli very small with seta; spiracles very light brown; length 8 mm.

Second instar: Body color ivory; headcapsule beige; anal plate brown; only short setae on horns and scoli; subdorsal scoli now already well-developed; spiracular line, dorsal line and field between subdorsal scoli brownish shadowed; spiracles brown; scoli on 8th and 9th segments not different; length 13 mm.

Third instar: Body color beige; headcapsule beige; anal plate beige; scoli with lateral white secondary ones; broad dorsal band brown between rows of scoli; supraspiracular scoli weak, subspiracular ones stronger developed; spiracles brown with light yellow frame; brownish band laterally between spiracular and dorsal scoli (weaker than dorsal band); 2 scoli on 8th segment strong and long; on 9th segment only 1 scolus also long and strong in the middle of the segment; length 20 mm.

Fourth instar: Body color beige; headcapsule beige; anal plate beige; thoracic legs beige; scoli as before; 3 well-developed brown bands: dorsal, spiracular and between subspiracular row of scoli; between the bands the beige body color; subspiracular scoli on a beige pot; beige also between subdorsal row of scoli and small supraspiracular scoli; spiracles brown with yellow trimming; scoli on 8th and

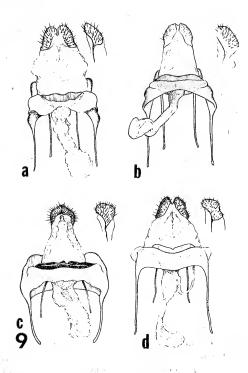


Fig. 9. Female genitalia, with lateral view of ovipositor alongside: a. A. fuscosa, b. A. peigleri, c. A. pellucida, d. A. discolor.

9th segments prominent; on all brown bands many white spots and round ecrescenses; thoracic horns  $11\frac{1}{2}$  mm long, clubbed with 2 obtuse ends with very small seta each; length 25 mm.

Fifth instar: Body color beige; headcapsule beige; anal plate beige; thoracic legs beige; body covered with many white spots and round ecrescenses; a very fine blackish dorsal line in the middle of a blackish brown band between the subdorsal rows of not too prominent black scoli; horns on thoracic segment II blackish, clubbed, only 5 mm long; a lateral band, a little narrower than the dorsal one, between the small supraspiracular and the also small spiracular scoli; scoli on 8th and 9th ssegments only slightly stronger than the subdorsal ones; length 45 mm. Headcapsule shown in fig. 4b, suranal plate in fig. 2b.

## PUPA (pl. VIII, fig. 1)

Chestnut brown as in other species in the A. stigma group; cremaster very strong and prominent; arising from a wide and short base; especially the bifurcation very pronounced.

#### DISTRIBUTION

This species ranges far into central Texas (Kerrville) beyond the grassland prairies but is much commoner in the forests of eastern Texas. We figure a pair from

Leesville, Louisiana, where Roy and Connie Kendall collected the larvae on which the larval descriptions are based. In western Louisiana A. fuscosa ranges eastward at least to Choudrant but A. stigma occurs commonly at Vicksburg, Mississippi (B. Mather, pers. comm.), only ca. 150 km farther east. In southern Louisiana the range probably does not extend as far east. The species probably occurs in Oklahoma but we have no records for that state. We do not believe that A. stigma occurs in Texas unless near the state line with Arkansas.

#### TYPE MATERIAL

Type-locality: Giddings, Lee Co., Texas. Additional type data: holotype female taken 15 August 1908 by R. A. Cushman, type no. 71495 United States National Museum. Type examined by the junior author. Most of the paratypes were collected in eastern Texas by A. and M. E. Blanchard.

#### BIOLOGY AND REMARKS

The color forms of the adults and larvae discussed in this section under A. consularis also exist in the present species, but these variations are even more striking in both adult ground color and mature larvae. One rare larval color form is very dark brown (almost black as in A. senatoria). The head, prolegs and anal plate are orange. It is not dissimilar to the hybrid larva shown in pl. I, fig. 9. No larvae of A. stigma or A. consularis which we have seen approach this form in darkness, but larvae of A. fuscosa are usually of the lighter forms.

The most important and obvious trait of the larva of *A. fuscosa* is the presence of the broad dark dorsal band which occurs in all instars except the first. It is absent in some mature individuals of the pink color form.

Larvae found on several species of oak such as Q. stellata in College Station and Q. nigra, Q. falcata and Q. marilandica in Texas counties and Louisiana parishes to the east. The junior author searched unsuccessfully for larvae at the type locality (Giddings) on Q. nigra growing along a stream. The caterpillars are exceedingly delicate in captivity, and usually die from disease. Of large numbers collected at various instars during three consecutive autumns in Walker Co., Texas, by the junior author, very few survived to pupate and no pupae produced adults. R. Kendall reported similar difficulty. However, C. Lemaire successfully reared a brood in southern France on Castanea vulgaris.

The flight period extends from 25 May to October but the peak is in early September of what we believe is one brood per year. The long flight period reflects the large population level in some areas of its range. Males are commoner at lights than females, as in A. stigma.

#### MATERIAL EXAMINED

UNITED STATES. LOUISIANA: Choudrant (AMNH, BMNH, LACM, Lemaire Coll., Peigler Coll.); Gibsland (AMNH, LACM, Lemaire Coll., Peigler Coll., ROM); Leesville, Vernon Parish (Kendall Coll., ROM); Many (Kendall Coll., LACM); Spring Ridge, Caddo Parish (larvae) (LSU). TEXAS: Bryan (larva) (TAMU); Cherokee Co. (TAMU); College Station (LACM, Peigler Coll., TAMU); Fort Worth (CalAcSci); Giddings (USNM); Handley (larva) (USNM); Huntsville State Park (USNM); Jasper Co. (larvae) (LACM); Kerrville (USNM); Milam, Sabine Co. (Kendall Coll.); Nacogdoches (BPBM, Peigler Coll.); Shepherd (USNM); Stubblefield Lake Recreation Area, Walker Co. (larvae) (AMNH, LACM, Peigler Coll., ROM, USNM); Tennessee Colony (USNM), Tyler (TAMU). Examined long series of males and females, dissected 5 males, 6 females.

#### Anisota manitobensis McDunnough

Anisota manitobensis McDunnough, 1921: 73; Brodie, 1929: 98-100, figs. 1-3 (biology); Ferguson, 1971: 71; Lemaire 1976: 47.

#### ADULT

Male (pl. II, fig. 7): Head, thorax, abdomen, and legs brownish orange; strong purplish suffusion on both wings; basic color dull orange; no hyaline patch on forewing; postmedian line dark purple and well-developed; white discal spot prominent (in one specimen the white spots have a white anterior branch as in Sphingicampa blanchardi Ferguson); underside of wings as on upperside. Outer margins of both wings weakly rounded. Dark sprinkling of wings usually lacking. Length of forewing 19-23 mm (10 measured).

Female (pl.  $\Pi$ , fig. 8): Like male but larger. Length of forewing 26-30 mm (4 measured).

Head: Laterofrontal suture totally obscured; a slightly perceptible convexity all along it; at occiput a small oval concave spot. Frontal protuberance broadly rounded. Male antenna with 15 rami. Posterior aspect of head very scalloped with conspicuous rounded processes.

Legs: Epiphysis found only in male, about half as long as tibia, dorsally rounded, ventrally straight, ending in a ventrally bent point, covered with short hairs, the ventral margins bearing quite long and straight hairs. Empodium small, one tubercle with one seta.

#### GENITALIA

Male (fig. 6d): Uncus V-shaped, apices (½ of total length of each arm) strongly set back and heavily sclerotized; gnathos broadly rounded triangular shield as in A. stigma, but with blunt apex; valves strongly rounded, giving entire structure a circular appearance; apex of valves bifid, both ends of almost equal length; ventral part of bifurcation strongly sclerotized, dorsal part only a little wider; free anellus crescent-shaped. Aedoeagus very broad and very short, on both sides slightly convex; carina bent in a smooth curve, its apex rounded with only a few tubercle-like processes instead of the usual teeth; vesica with two strong cornuti at the usual locations; both with a few uneven teeth, the preapical one with knoblike base (as in A. stigma); proximal end straight as usual. (Gen. prep. ROM 3-016).

Female (fig. 8c): Ovipositor valves medium sized, strongly rounded at apex; lobuli vaginales approximately as high as in A. finlaysoni; sterigma strongly sclerotized, higher than usual, having on either side a peculiar triangular ventrally-pointed form; ostium bursae quite wide; ductus bursae slightly sclerotized, a very strong tubular structure, gradually curved ventro-laterally; bursa copulatrix usually small, longitudinal, shaped somewhat like a shoe; signum, if present, a round patch with an arrowhead-like scaling in the center; ductus seminalis connecting at the very beginning of ductus bursae. (Gen. prep. ROM 3-017).

#### EGG

According to Brodie (1929): laid in clusters, "ovate and flattened, 1.51 mm by 1.25 mm, bright sulphur yellow, shiny, quite opaque and perfectly smooth". After one week darkening to brown and hatching after 13 days.

#### LARVA

The following description of each of the instars is taken directly from the paper by Brodie (1929):

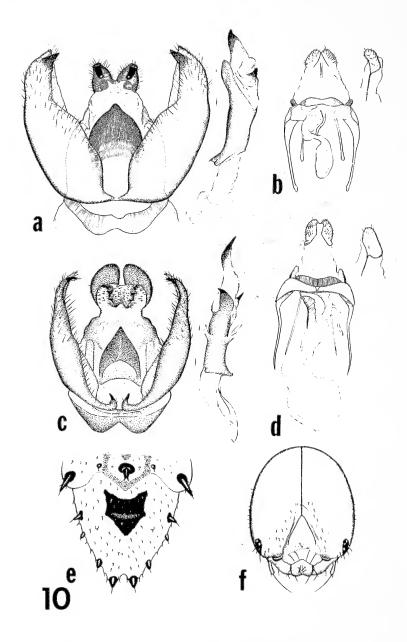


Fig. 10. Morphological structures. a-b. Male and female genitalia of A. dissimilis. c-f. Male and female genitalia, suranal plate and head capsule of larva of Dryocampa rubicunda.

First instar: Creamy white, head shiny black; a wide dorsal and a narrow lateral brownish black line; spiracle brownish; the usual horns on the second thoracic segment. Changing of color in development to light and dark tan and black. Length: 3 mm.

Second instar: Shiny black, head dark tan; two dorsal cream colored stripes; a short light cream colored stripe diagonally through each spiracle; spiracles black; ventral side dull cream to buff; thoracic horns 2.2 mm, bifurcating at tip. Length: 7 mm.

Third instar: Head light tan; dorsal cream colored stripes present; spines, previously all black, now black at base and snow white toward tipi spines on anal segment almost entirely white; short white streak diagonally through each spiracle; ends of prolegs brown (previously grayish); colors of larva changing rapidly through development; black parts becoming dark brown, e.g. the body; dorsal cream colored lines becoming a dark shade of buff. Very shiny in this stage. Length: 10 mm.

Fourth instar: Head light tan, body shiny dark brown; two lighter brown dorsal stripes; spiracles black; horns on second thoracic segment shiny black with white branches, 5 mm long; other spines similarly colored; anal segment now dark brown (previously black) with scattered white spines; prolegs dark brown; white on spines giving larva appearance of being covered with hoar-frost (similar in A. stigma). Colors changing during development to light pinkish brown. Length: 22 mm.

Fifth instar: Little change from previous instar; head paler tan; true legs changed from black to pale tan; body light pinkish brown; many more spines now white; spiracles black with light pinkish border; horns on second thoracic segment 6 mm long; the area between the two dorsal lines with a thin central black line and with dark shading on either side of this line. Length: 50 mm.

## PUPA (pl. VII, fig. 3)

Reddish brown; evenly wide leading to a dome-like last segment with a strong medium sized bifid cremaster; the forks strong and wide but not very pointed.

#### DISTRIBUTION

This moth was previously only recorded from southern Manitoba until we obtained specimens from three localities in Wisconsin from Mr. William E. Sieker (part of these we deposited in ROM and AMNH as indicated under "Material Examined"). The species probably also occurs in North Dakota and should certainly be found in Minnesota.

#### TYPE MATERIAL

Type locality: Aweme, Manitoba. Additional type data: male holotype collected 4 July 1907 and female allotype collected 23 June 1904 both by Norman Criddle. Location of types is CNC with paratypes in CNC and USNM. We examined all of these.

#### BIOLOGY AND REMARKS

Brodie (1929) fed his larvae on *Quercus macrocarpa* Michx. He got his larvae from Mr. T. M. Short. The insect has been taken in recent years by Manitoba lepidopterist Mr. C. S. Quelch.

The flight period is June and July, the records for Manitoba being for both months, those of Wisconsin only for July.

As given under our remarks on the distribution, this species can now be listed as part of the United States fauna. The Wisconsin material required dissection for

verification of the determination because most were heavily spotted as in A. stigma. The original description (McDunnough, 1921) and Ferguson (1971) state that A. manitobensis completely lacks this sprinkling and most of the museum material we saw bears this out. No problems, however, should arise in distinguishing the two species since they are apparently allopatric and the latter has more pointed forewings. Some specimens of A. stigma (in AMNH) from Rhode Island and Massachusetts appear very much like A. manitobensis with reduced or absent sprinkling and pink coloring in the postmedian area. The present species is sympatric with A. virginiensis; see maps 31, 32 in McGugan (1958).

#### MATERIAL EXAMINED

CANADA. MANITOBA: Aweme (CNC); Darlingford (AMNH, CNC); Deer Lodge (CNC); Kelwood (CM); McCreary (Peigler Coll.); Pembina Valley (CNC, ROM); Pine Ridge (Peigler Coll.); Riding Mtns. (CM, USNM); St. Vital (CNC); Transcona (Lemaire Coll.); Winnipeg (CNC, USNM). UNITED STATES. WISCONSIN: Arlington (ROM); Madison (one from University of Wisconsin Arboretum) (Sieker Coll.); Waushara County (AMNH, ROM). Saw 17 males, 8 females, dissected 3 males and 2 females.

#### Anisota stigma Fabricius

Bombyx stigma Fabricius, 1775: 563; Olivier, 1790: 42; Kerr, 1910: 110 (types). Phalaena Bombyx stigma; J. E. Smith, 1797, II: 111, pl. 56.

Dryocampa stigma; Harris, 1841: 292.

Adelocephala stygma; Boisduval, 1871: 86.

Anisota stigma; Huebner, 1818-1822: 193; Beutenmueller, 1898: 430, pl. 20, fig. 4; Holland, 1903: 94, pl. 9, figs. 9, 10; Packard, 1905: 98-102, pl. 20, figs. 4-9; Forbes, 1923: 667; Draudt, 1930: 813; Bouvier, 1931: 17; Schuessler, 1936: 215-218; Kimball, 1965: 69.

Anisota stigma stigma; Ferguson, 1971: 67; Lemaire, 1976: 47.

#### ADULT

Male (pl. II, fig. 1): Head, thorax, abdomen, legs, fore- and hindwingss ochreous reddish-brown; forewings sprinkled with many dark scales, hindwings less; no hyaline patch on forewings; postmedian line on both wings dark purplish and well-developed; antemedian line weak to well expressed; white discal spot prominent; terminal area of forewings with more or less outspoken purplish hue; basal area shows this hue to a lesser degree; middle field never with it. Outer margin of all wings rounded. On the underside the ochreous ground color more pronounced against the brownish tones; the purplish in many specimens strong apically on fore-and hindwing; only postmedian lines strongly expressed. Length of forewing 19-24 mm (25 specimens measured).

Female (pl. II, fig. 2): Like male, larger, often with more brownish than reddish overtones and rarely even leaning to yellowish. When marked purplish suffusion appears with decreased black sprinkling or no purplish suffusion with much sprinkling indentification can be difficult and genitalic dissection can be helpful. Also the fact that the anterior wings are broader and more strongly convex in the outer margin should make the decision easier. The white discal spot is conspicuous. Length of forewing 27-36 mm (17 specimens measured).

Head: Laterofrontal suture obscured; frontal protuberance very perceptibly protruding; male antennae with 15 rami; posterior aspect of head with triangular

rounded large thorns.

Legs: Epiphysis in males a little more than half the length of the tibia, dorsally rounded, ventrally straight, ending in a point, covered—especially ventrally—with rather long, dense hairs; in females, if present, only very rudimentary; empodium small with a very short seat (see: Oiticica, 1940: pl. 12, fig. 2).

#### **GENITALIA**

Male (fig. 6a): Overall impression pronouncedly square. Uncus with strongly sclerotized apices in the form of a broad M; gnathos a triangular shield with rounded apex, wider than in A. peigleri, A. senatoria and A. virginiensis and not as long as in these; valves strongly rounded and bent distally, apex bifid, the dorsal bifurcation longer than the ventral one which is strongly sclerotized; free annellus conspicuously crescent shaped; aedoeagus short, carina bent and rounded at apex, strongly sclerotized with a comb of thorns; vesica with pointed and thorned cornutus apically and another halfway with a knob-like base ending in a trifurcation; proximal end of the same general form as in the other species. (Gen. prep. ROM 3-045).

Female (fig. 8a): Ovipositor valves large; strongly rounded at apex; lobuli vaginales low; sterigma compact, strongly sclerotized; ostium bursae of medium width; ductus bursae not sclerotized, but a straight, strong, tubular structure; bursa copulatrix sometimes very small, normally, however, large, elongate, ovate; signum mostly absent, sometimes a round slightly sclerotized patch present; ductus seminalis attached in upper fifth of ductus brusae, laterally. (Gen. prep. ROM 3-042).

EGG

Light yellow, more round and not so much flattened; 1.3 x 1.5 x 0.7 mm. LARVA (pl. I. fig. 1)

First instar: Body color pastel yellow; headcapsule black; anal plate also black (note here difference from Packard, 1905: 99, who says that the anal plate is pale, of the color of the body, not pigmented); thoracic horns on segment II very long, bifurcate; on segment III bifurcate already at base, shorter, base brownish; spines on all segments, on a base, this base brownish on segment 1, on the other segments blackish, on segment 9 one only large scolus on a base, bifurcate with setae on both ends; dorsal line very thin, olivish, secondary spines all over the body in a horizontal row subspiracularly; spiracular line greyish-olive; length 3 mm.

Second instar: Body color darker into brownish; headcapsule black; anal plate black; dorsal line narrow, blackish; subdorsal lines wider, blackish; supraspiracuar and spiracular lines not so wide and fainter in color; spiracles black; length 9 mm.

Third instar: Body color reddish-brown; headcapsule dark mahogany, anal plate black; horns on thoracic segment II black, perceptibly barbed; anal legs with a large, red, triangular spot; abdominal prolegs dull red with a black spot; the lines showing in the second instar become faint, reduced to traces; some white granulation begins to appear over the entire body; first traces of two lateral pinkish lines appear; the three dorsal lines are blended in one another forming a broad, pale reddish-brownish band; on each side of the head a pale, whitish line; length 16 mm.

Fourth instar: Body color reddish-brown, headcapsule dark mahogany; anal plate black; horns on thoracic segment II less spinulated than in the third instar, with white granulations, 10 mm long; on thoracic segment I six large, strong, forked scoli, not bifurcate, with a single seta; spiracles black with a thin whitish bordering;

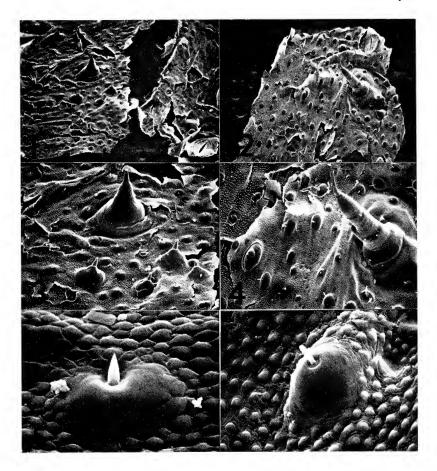


PLATE V. Scanning electron micrographs of larval integument. 1, 3, 5. A. senatoria. 2, 4, 6. A. peigleri. Scale of figs. 1-2 is 22 mm:1 mm, of figs. 3-4 is 16 mm:300 μm, of figs. 5-6 is 16 mm:30 μm.

color of anal legs verying between dark reddish and black; thoracic legs and abdominal prolegs dark pitchy; any lines almost not perceptible; length 32 mm.

Fifth instar: Body color brown; headcapsule dark mahogany; anal plate brownish; supraspiracular lines now better perceptible, greyish-pinkish; the whole larva very much as the one of the fourth instar otherwise; length 48 mm.

NB: Packard, 1905: 101, mentions an occasional sixth instar that we, however, were not able to observe in any of our rearings.

Headcapsule shown in fig. 4a, suranal plate in fig. 2a.

PUPA (pl. VII, fig. 1)

Posterior segments decreasing only slightly in diameter; the spines are conspicuous; cremaster long and strong, bifurcation weak; in this the pupa is different

from all other known puape of any Anisota; color chestnut brown.

#### DISTRIBUTION

This species does not occur as far to the north as A. senatoria and A. virginiensis. We find it, however, widely distributed along the eastern seaboard from Florida to Massachusetts; westward through extreme southern Ontario to Minnesota, Kansas, Arkansas. There are no specimens known from Mexico.

#### TYPE MATERIAL

Type-locality: "America Meridionalis". Location of the two cotypes: Collection of insects of the University of Glasgow, Scotland. The female specimen (lower one on pl. VI, fig. 3) is hereby designated by us as lectotype.

Boisduval, 1871, had expressed some doubt as to the identity of this species which was figured for the first time by J. E. Smith, 1797, in both larval and adult stage. Boisduval bases his contention on the fact that Fabricius states as typelocality "America Meridionalis" and not "America Borealis", as might be expected if the species came from the United States. However, when Fabricius named the species there did not yet exist any United States of America and America just meant the British Colonies in North America (see Oxford Dicitonary), hence "Am. Merid." would be what we call today the "Southern States" including Spanish possessions like Florida and Mexico. Moreover, the types, preserved in the Hunter collection and reproduced here after an original photograph made for this purpose in 1967, show without any reasonable doubt specimens of A. stigma.

#### BIOLOGY AND REMARKS

This species is so widespread and well-known that very little new information can be offered here. The moth has been collected with ultraviolet light by the junior author atop Mt. Mitchell, North Carolina, the highest point in eastern North America. It is generally common in the northern and southern states of the eastern half of the continent. The northern range into Canada needs additional records to delineate it.

One error which keeps creeping up into dealings with A. stigma is the record in McGugan (1958): "near North Bay in northern Ontario". The original report shows as locality Bear Island, Joan Township, Nipissing District. it was made in 1953 from a larval collection. However, from Bear Island there is an ex larva female of A. virginiensis in CNC ex FIS from 1956. The identification of the original report was in the meantime changed to "Anisota sp." (P. D. Syme, Canadian Forestry Service, Insect Pathology Research Institute, Sault Ste. Marie, Ontario, in litt.). Also North Bay is far from "southern Ontario" (Ferguson, 1971: 68) which should have elicited some suspicion in using this report again.

A. stigma is uncommon in central Florida and absent southward in that state. Specimens in the AMNH and others sent us by D. Baggett all originating in the panhandle of Florida average considerably smaller than material from elsewhere. Additional material, with associated preserved larvae, from the Gulf coast area would be interesting.

At Clemson, South Carolina, the junior author found larval colonies in the university arboretum on *Q. michauxii* and *Castanea mollissima*. Also at Clemson he once found larvae on *Q. alba*, his only observation of this oak species ever being utilized by *Anisota* in a southern state.

Seasonal flight times vary with latitude, altitude, and weather for the particular year, but most adults are taken in June, July or August. The circadian flight times

were mentioned in a previous section. Variation in larval coloring is cited under the text of A. consularis. Resemblance of adults in New England to those of A. manitobensis is discussed under the latter species.

The Nova Scotia record given below needs verification due to absence of records from Maine, New Hampshire, Vermont and Quebec.

#### MATERIAL EXAMINED

CANADA. NOVA SCOTIA: Truro (CNC). ONTARIO: London (ROM); Port Colborne (CNC); Queenston (CNC); St. Williams (CNC, FIS); Simcoe (CNC). UNITED STATES: ALABAMA: 8 km NE Eutaw (AMNH); Ida (CalAcSci); Loxby (AMNH); Wilmer (AMNH). ARKANSAS: no other data (AMNH); Blue Springs Campground (Heitzman Coll.); Bluff City (AMNH); Camden (LACM, Peigler Coll.); Chidester (Lemaire Coll.); Crawford Co. (larvae) (UArk); Hope (LM, UMo). CONNECTICUT: Deep River (AMNH); Manfield (AMNH); Old Lynn (AMNH); Putnam (AMNH). FLORIDA: Alachua Co. (FSCA); Archbold Bio. Sta., L. Placid (AMNH); Bonita Springs (AMNH); Gainesville (FSCA); 3 km E. Lamont (UM); Monticello (MCZ); Quincy (AMNH, FSCA); Shalimar (Hilton Coll.); Suwannee Springs (pupa ex larva) (ROM); Torreya State Park (AMNH, LACM); White Springs (larva) (AMNH). GEORGIA: Atlanta (AMNH, CM); Cooper Creek State Rec. Area, Fannin Co. (AMNH, LACM, UGA); Emory Univ. (FSCA); Lawrenceville (UM); Macon (UM); Ohoope River (CM); Savannah (UM); Tifton (UGA). ILLINOIS: Chicago (FMNH); Lacon UII); Osborn (UM); Palos Park (FMNH, UII); Putnam Co. (UII). INDIANA: Bristol (FMNH); Hessville (FMNH, UII, UM); Knox (FMNH); Miller (FMNH); Mitchell (FMNH); Tresmont (FMNH, YPM). KANSAS: Johnson Co. (Heitzman Coll.); Ottawa (AMNH). KENTUCKY: no other data (MCZ); Morehead (CNC); Rio (UM). LOUISIANA: Baton Rouge (LSU); Denham Springs (LSU); Indian Mound (FMNH); Tallulah (larva) (UMo). MASSACHUSETTS: Barnstable (AMNH); Chatham (MCZ); East Warshaw (AMNH); Edgartown (LM); Lawrence (ROM); Marthas Vineyard (MCZ); Sherborn (MCZ). MICHIGAN: Agric. College (MSU); Allegan (MSU); Augusta (MSU); George Reserve (MSU, MU); Highland Park (UM); Lansing (UM); Lenawee Co. (ROM); Nine Mile Road (UM). MINNESOTA: Minneapolis (YPM). MISSISSIP-PI: Aditon (ROM); Bovina (AMNH, BPBM, LACM, Lemaire Coll., Peigler Coll., ROM); Hattiesburg (AMNH, ROM); Jackson (AMNH, ROM); Johnson State Park (LACM); Mississippi State (LACM); Oxford (BPBM, LACM); Pearl (AMNH, ROM); Waynesboro (LACM); Wilmer (LACM). MISSOURI: no other data (CalAcSci); Adair (Heitzman Coll.); Ashland (larva) (UMo); Bagnell (AMNH, LACM); Benton (Heitzman Coll.); Boon (dto.); Camden (dto.); Columbia (also larvae) (UMo); Curryville (UMo); Greene (Heitzman Coll.); Hartsburg (UMo) Jasper (Heitzman Coll.); Jefferson (dt.); Livingston (dto.); Pike (dto.); Putnam (dto.); Randolf (dto.); St. Louis (dto.); Ste. Genevieve (dto.); Stone (dto.); Washington (dto.). NEW JERSEY: no other data (AMNH); Arlington (AMNH); Cape May Co. (AMNH); Cedar Run (AMNH); East Marion (CNC); Elizabeth (CM); Green Village (larva) (AMNH); Lakehurst (AMNH); Manahawkin (AMNH); Morris Co. (AMNH); Newark (AMNH, FMNH); Ocean Co. (AMNH); Paterson (AMNH); Plainboro (AMNH); Smithville (AMNH); Stanhope (AMNH); Watchung Mts. (AMNH); Wodersey (AMNH). NEW YORK: no other data (AMNH, LM); Bedford (AMNH, FSCA); Bronx (AMNH); Brooklyn (CNC); Buffalo (CM); Grand Island (CM); Leviston (AMNH); Long Island (AMNH, CNC); New York (AMNH); Northport (AMNH); West Farms (AMNH). NORTH CAROLINA: Bryson City

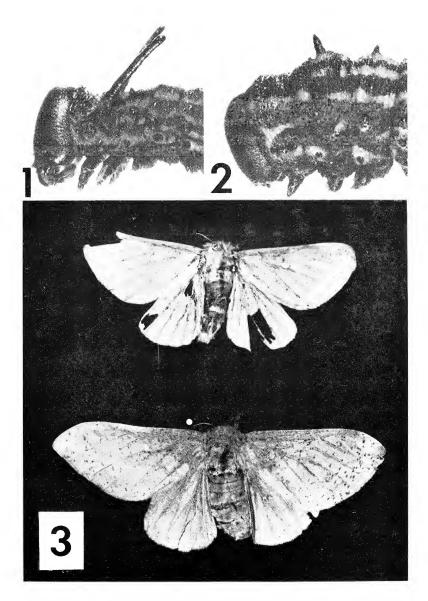


PLATE VI. 1. Anterior end of larva of A. senatoria showing mesothoracic scoli typical for the genus. 2. A. finlaysoni which has these horns greatly reduced. Both original photos by L. R. Finlayson. 3. Cotypes of "Bombyx stigma Fabricius" in Hunter Collection at Univ. of Glasgow, Scotland.

(UM); Cedar Mt. (UCal); Crestmont (UM); Fontana (CM, LACM); L. Toxaway (AmNH); Maxton (AMNH); Mt. Mitchell (Peigler Coll.); Raleigh (USPM, larva LSU0; Southern Pines (LM). OHIO: Columbs (UM). PENNSYLVANIA: Butler (CM); Delaware Water Gap (AMNH); Mt. Airy (AMNH); Pittsburgh (CM); Sharpsburg (CM); Shawville (CM); Slippery Rock (CM). RHODE ISLAND: Deardon (MCZ); Elmwood (CM); North Scituate (AMNH); Rockland (AMNH). SOUTH CAROLINA: Clemson (AMNH, BPBM, CLU, LACM, Lemaire Coll., Peigler Coll., ROM); Columbia (LACM); Coosawhatchie (AMNH); Florence (CLU); Galivants Ferry (AMNH); Myrtle Beach, Arrowhead L. (CNC); Six Mile (AMNH, LACM); Sleepy Creek (CM). TENNESSEE: Allardt (UM); Burrville (CNC); Gatlinburg (FMNH); Knoxville (CNC); Monteagle (AMNH, CNC, FMNH); Sunbright, Morgan Co. (FMNH). VIRGINIA: Falls Church, Fairfax Co. (UM); Nelson Co. (CM). WISCONSIN: Chippewa Falls (AMNH). Examined 161+ males, 118+ females, dissected 19 males and 16 females.

#### ARTIFICIAL HYBRIDIZATION

A few crosses have been made within the genus, all within the last few years. Females of any species will apparently attract males of any species providing they emit pheromone at the right times of day and year for the particular males in the area.

## A. peigleri ♂ X A. consularis ♀

Using a female of *A. consularis* reared from a larva taken in Statesboro, Georgia, males of *A. peigleri* were attracted in Greenville, South Carolina. The percent hatch was extremely high. Mature larvae (pl. I, fig. 9) were strikingly intermediate, having reddish heads, black bodies, and yellow-orange stripes. Adults were intermediate, tending more toward *A. consularis*. A pair is figured on pl. II, figs. 9-10. Specimens are in AMNH, LACM and ROM.

#### A. senatoria ♂ X A. oslari ♀

Using Arizona stock of A. oslari, a male of A. senatoria was attracted at 2:15 PM (EDT) in Pomfret, Connecticut by Benjamin D. Williams III. He succeeded in rearing several to adults. The larvae were not unlike those of the above cross with light heads and dark bodies, and the adults showed a nice blend of characters. After overwintering, the females emerged in May and the males in June and July.

#### A. pellucida ♂ X A. virginiensis ♀

Using adults from caged pupae this cross was made in Toronto by the senior author with a male from McClellanville, South Carolina and a female from Chaffeys Locks, Ontario. Larvae and adults were intermediate, even in genital characters. The series is in the ROM.

#### A. virginiensis ♂ X A. discolor ♀

Adults emerged from caged pupae, the father being from Pine Grove, Pennsylvania and the mother from Hamilton, Texas. Larvae looked more like the father species and one larva had distinct light green in place of the dark gray stripes. Some diapaused and others did not. A large series of adults was obtained and these resembled A. virginiensis mostly and exhibited very little variation among themselves. Most of the series is in AMNH with pairs in other collections. A pair is figured on pl. II, figs. 11-12.

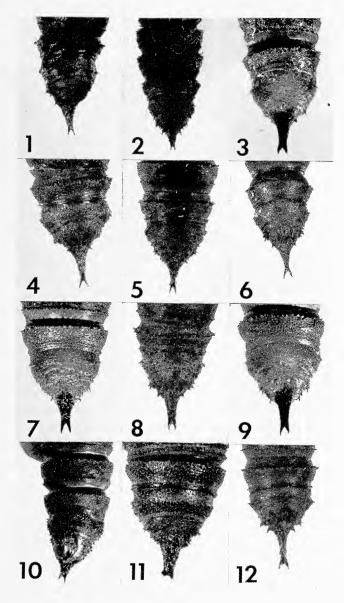


PLATE VII. Photographs of pupae showing cremasters. 1. A. stigma. 2. A. consularis. 3. A. manitobensis. 4. A. senatoria. 5. A. peigleri. 6. A. finlaysoni. 7. A. pellucida. 8. A. virginiensis. 9. A. pellucida. 10. A. assimilis. 11. A. dissimilis. 12. D. rubicunda.

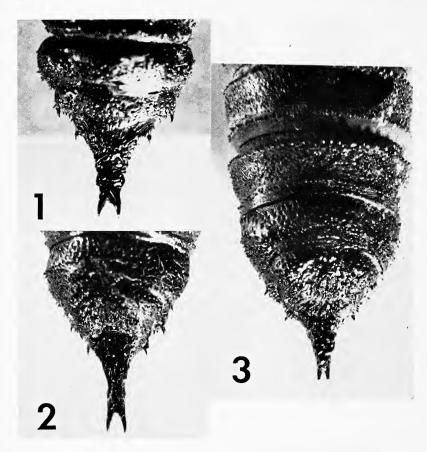


PLATE VIII. Photographs of pupae showing cremasters. 1. A. fuscosa. 2. A. discolor. 3. A. oslari.

## A. virginiensis ♂ X A. discolor ♀ F2

A brother-sister pairing of the above hybrids resulted in ova which gave very little hatch. Larvae were weak and only three reached the final instar but none pupated. Possibly a disease killed these larvae.

## A. pellucida $\circlearrowleft$ X (A. virginiensis $\circlearrowleft$ X A. discolor $\mbox{\tt Q})$ $\mbox{\tt Q}$

A hybrid female attracted a male of *A. pellucida* in Greenville, South Carolina at 12:28 PM (EDT) and she laid a full complement of ova. All larvae died when very small which suggests hybrid inviability.

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# THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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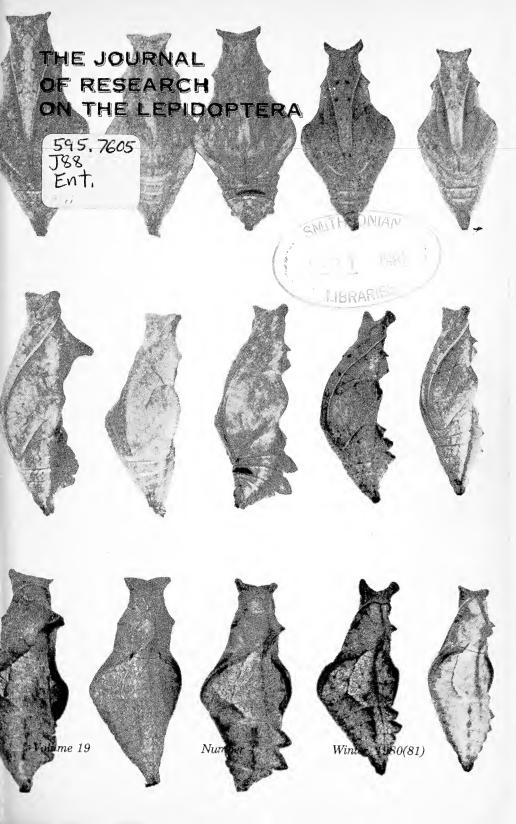
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A Revision of the American Genus Anisota (Saturniidae)

J. C. E. Riotte & Richard S. Peigler

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COVER ILLUSTRATION: Scanning electron micrograph of A. peigleri larval integument. Scale = 22 mm:1 mm. See page 170, this issue.



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## Enzyme Electrophoretic Studies on the Genetic Relationships of Pierid Butterflies (Lepidoptera: Pieridae) I. European Taxa\*

H. J. Geiger

Zoologisches Institut der Universitat Bern, Sahlistrasse 8, CH 3012 Bern, Switzerland

Abstract. The phylogenetic relationships of 24 taxa representing the four European subfamilies of the Pieridae were studied using enzyme electrophoretic techniques. The mobilities of 20 enzymes, each determined by a different locus, were compared. A dendogram is presented indicating the grouping of the taxa on the basis of biochemical data. Results agree well with those obtained from conventional systematic studies. In cases where the relationships between taxa are under discussion, one of the alternatives is supported. The Pierinae and Anthocharinae are biochemically clearly characterisable entities although the branching point of these two subfamilies in the dendogram lies only slightly below those of different genera. These two subfamilies are separated from the Coliadinae by a clear step of genetic divergence. Within the recently subdivided genus Pieris Shrank s. ltr. of the Pierinae, three groups of taxa that branch at the same level of similarity in the dendogram can be recognized. The taxa of the new genus Artogeia Vrty. are no more closely related to each other than they are to the taxa of Pieris s. str. Biochemical data support the species rank of the taxa cheiranthi Hbn., simplonia F. and crameri Btlr., but indicate a remarkably low level of genetic differentiation between the taxa napi L. and bryoniae Hbn.

#### Introduction

The systematics of pierid butterflies have been extensively studied by several independent taxonomic methods and the Pieridae are now one of the best known butterfly families. Despite this, diverging views exist on the relationships and status of several taxa at different hierarchical rank. Systematic problems at the levels of 1) subfamilies and tribes, 2) genera, subgenera and species groups and 3) species and subspecies are discussed below.

1) In a generic revision of the family, Klots (1931/32) grouped the Pieridae into three subfamilies: Pseudopontiinae, Dismorphiinae and Pierinae and subdivided the Pierinae into three tribes: Euchloini, Rhodocerini and Pierini. This classification, with or without modifications, has

<sup>\*</sup>This study was supported by the Swiss National Science Foundation Grant No. 3.640.80.

been followed by virtually all subsequent authors. In a comparative analysis of the morphology of the Papilionoidea, Ehrlich (1958), following other authors (e.g. Ford, 1945), elevated the Coliadinae (Rhodocerini sensu Klots, 1931/32) to subfamily status. This classification reflects the closer morphological relationship between the Pierini and Euchloini than between these two tribes and the Coliadinae or Dismorphiinae. Higgins (1975) adopted this system for the European Pieridae, but gave the Anthocharinae (Euchloini sensu Klots) subfamily rank. In the same work, Higgins included the genus Catopsilia Hbn. in the Pierinae in the tribe Callidryini Kirby but most other authors, including Klots (1931/32), have regarded this genus as best placed in the Coliadinae.

- 2) Of the European taxa, species of the genus Pieris Schrank have been especially problematical. This genus has long been recognized as being globally distributed and various authors have included a great number of taxa in it. (e.g. Roeber, 1908). In his revision of the Pieridae, Klots (1931/32) restricted the number of taxa and subdivided the genus into four subgenera. Of the European taxa, he arranged brassicae L. in the subgenus Pieris and the taxa napi L., rapae L., manni Mayer and ergane Geyer in the subgenus Synchloe Hbn. (together with e.g. callidice Esp.). Bernardi (1947) also used the system of subgenera, but, in part, arranged the species in different subgenera than previous authors. In his system, the subgenus Pieris was divided into three species groups: Pieris 1 s. str. with brassicae (of the European fauna), Pieris 2 with napi, rapae, manni and ergane and Pieris 3 which is not represented in Europe. Kudrna (1974), following Verity (1947), suggested that the species group which includes napi, bryoniae Ochsenheimer, ergane, manni, rapae and krueperi Staudinger should be placed in a separate genus, Artogeia Verity, and that Pieris only houses brassicae, cheiranth Huebner, deota Niceville and brassicoides Guerin-Meneville, However, Forster and Wohlfahrt (1976) claimed that the taxa included in Artogeia and Pieris are, in fact, congeneric.
- 3) Problems with European taxa at the species and subspecies level are well illustrated by the taxa of the Pieris (Artogeia) napi-group, the status of which have been widely discussed. In the past, it has not been possible to determine the phylogenetic distances between many taxa of this group and it has been necessary to use complicated taxonomic constructions such as the super- and semispecies concepts of Lorkovic (1962), Varga and Toth (1968) and Bowden (1972). Theories on the evolution of this group are confused (Petersen, 1949; Varga and Toth, 1978; Bowden, 1972) while relationships between North American, Asiatic and European taxa remain uncertain (Bowden, 1962). One reason for this confusion is the great variability of morphological characters within very similar taxa (for the variability of wing markings of napi and bryoniae see Mueller and Kautz, 1939). Investigations of closely related taxa indicate that the variability in coloration seems to be strongly influenced by environmental factors (e.g. Koyler, 1966; Shapiro, 1975, 1977).

Table 2

		T	
Enzyme	Abbreviation	Buffer System	Enzyme Stain
Adenylate kinase (2 Loci)	AK-1 AK-2	1	Brewer, 1970
Glyceraldehyde-phos- phate dehydrogenase	GAPDH	1	Harris and Hop- kinson, 1976
Arginine kinase	APK	1	Scholl (1)
Malate dehydrogena- se (2 Loci)	MDH-1 MDH-2	1	Harris ans Hop- kinson, 1976*
Aldolase	ALD	1	ibid
Indophenol oxydase	100	1	Brewer, 1970*
Malic enzyme	ME	2	Harris and Hop- kinson, 1976
Hexokinase	нк	1	ibid
Pyruvate kinase	PK	1	ibid
Glutamate-oxâloace- tate transaminase (2 Loci)	GOT-1 GOT-2	1	ibid*
6-Phosphogluconate dehydrogenase	6-PGD	. 1	Brewer, 1970*
Fumarase	FUM	1	ibid*
Isocitrate dehydro- genase (2 Loci)	IDH-1 IDH-2	1	Ayala et al., 1972
Glutamate pyruvate transaminase	GPT	2	Harris and Hop- kinson, 1976
Phosphoglucomutase	PGM	1	Brewer, 1970
Phosphoglucose Iso- merase	PGI	1	Scholl et al., 1978

#### Remarks:

Buffer Systems : System 1: Tris-citric acid buffer (Ayala et al., 1972) System 2: Tris borate EDTA buffer (Ayala et al., 1972)

\*With minor modifications, but the original staining medium would also be sufficient

(1) Scholl (personal communication): Agar overlay method. Staining mixture: Glycin buffer (1.52 M Glycin, 42 mM MgCl<sub>2</sub> · 6 H<sub>2</sub>0, pH 9.0): 5ml, PEP : 10 mg, ATP : 40 mg, NADH<sub>2</sub> : 10 mg, LDH : 90 iU, PK : 20 iU

Discussions are also in progress on the *Euchloe "ausonia*-complex", especially the status of the monovoltine populations flying in the Alps and Pyrenees and the bivoltine populations of the lower part of France and Italy (Back, 1979).

Recently biochemical methods have become important in the analysis of phylogenetic relationships. Enzyme electrophoresis in particular has proved very informative (Ayala et al., 1974; Avise, 1974; Selander and Johnson, 1973). In this method, the extent of genetic divergence is estimated from variation in electrophoretic mobilities of a sample of

homologous enzymes of the various taxa. This approach is basically a genetic method but differs from other methods, for example the determination of interspecific fertility-bridges or sterility-barriers by hybridization experiments, in that the degree of genetic divergence is estimated from a defined sample of the genotype. Again this is not the case when evaluation of phylogenetic relationships is based on morphological data.

It has been demonstrated that phylogenetic independence of a taxon is correlated with gradual biochemical-genetic divergence (Ayala *et al.*, 1974; Avise, 1974; Selander and Johnsen, 1973) manifested in an increasing number of electrophoretically distinguishable enzyme variants. Enzyme electrophoresis may provide a basis independent of environmental variation for assessing the evolution of the Pieridae. This paper reports

Table 1

Тахоп	Number of animals		Number of population samples (1)	Number of sampling sites (2)
Aporia crataegi L.	19	СН, F	1	2
Pieris brassicae L.	141	CH,F,D,IRL	9	17
Pieris cheiranthi Hbn.	16	E	1	1
Artogeia rapae L.	154	CH,F,I,D	9	17
Artogeia mannii Mayer	25	F	1	1
Artogeia napi napi L.	276	CH,F,I,D,GB	16	24
Artogeia napi bryoniae Hbn.	63	СН	4	4
Pontia daplidice L.	5	CH,F,I	0	4
Pontia callidice Hbn.	5	СН	0	1
Euchloe simplonia Freyer	11	СН	0	5
Euchloe crameri Btlr.	11	F	1	1
Euchloe tagis bellezina Bois.	13	F	1	1
Anthocharis cardamines L.	45	CH,F	3	10
Anthocharis euphenoides Staud	11	F	1	1
Colias phicomone Esp.	78	СН	5	5
Colias palaeno europome Esp.	60	СН	4	4
Colias myrmidone Esp.	6	ם	0	1(3)
Colias crocea Geoff.	9	I	0	1
Colias hyale L.	5	ם	0	1(3)
Colias australis Vrty	7	CH,D,F	0	4
Catopsilia florella F.	4	E	0	1
Gonepteryx rhamni L.	6	СН	0	1
Gonepteryx cléopatra L.	7	F	0	1
Leptidea sinapis L.	13	CH,F	1	1

#### Remarks :

Code for countries: CH = Switzerland, D = Federal Republic of Germany, E = Speain, F = France, GB = Greet Britain, I = Italy IRL = Republic of Ireland

a population sample consists of a minimum of 10 individuals from each sampling site

<sup>(2)</sup> this includes samples with less than 10 individuals

<sup>(3)</sup> laboratory reared

electrophoretic investigations of European taxa. A more comprehensive study, incorporating non-European material, is in preparation.

## **Materials and Methods**

The material used in this study is listed in Table 1. Samples (only adults were studied) were usually stored at -30°C until electrophoresis. Control experiments showed that the electrophoretic mobility of the enzymes is identical in extracts from deep frozen and fresh specimens. There was however a considerable loss of GAPDH and ALD activity (for abbreviations used see Table 2) in frozen butterflies.

Supernatant fractions were prepared for electrophoresis from homogenates of an individual's thorax and head or its abdomen. The enzymes ME and GPT were assayed in supernatants from abdominal homogenates and other enzymes in supernatants from homogenates of the thorax and head. All enzymes were electrophoresed on vertical starch gels using standard procedures of our laboratory which have been described in detail elsewhere (Scholl et al., 1978).

The enzymes assayed are listed in Table 2. A total of 20 enzyme loci has been scored in all taxa, with the exception of *Euchloe tagis bellezina* and *Leptidea sinapis*, for which only 18 enzyme loci were studied.

All taxa have been compared directly with each other. A precise characterization of all electrophoretic variants (electromorphs) was obtained by repeated cross-comparisons, with the exception of some rare variants. For each enzyme the designation of electromorphs (Tables 3.1 and 3.2) was made by comparison to the most frequent variant of *Pieris brassicae*, which defined the index 100. Other electromorphs were designated by measuring the difference (in millimeters) in their mobility compared to that of the reference *P. brassicae* variant (under our conditions of electrophoresis) and then adding or subtracting this value from 100. Thus IDH 103 refers to an IDH-electromorph that migrates 3 mm faster than the most frequent IDH-variant of *P. brassicae*.

The correct genetic interpretation of electrophoretically detectable enzyme phenotypes in polymorphic enzyme systems was proved by mating experiments (for comments see also Scholl *et al.*, 1978).

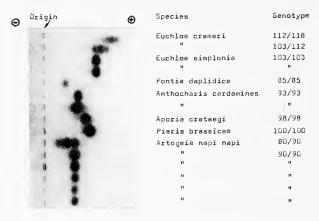
To estimate the genetic similarities between the taxa, the statistic  $\bar{I}$  as defined by Nei (1972) was used. The similarity values  $\bar{I}$  are presented in comparisons between pairs of taxa (Table 4) and are a measure of the proportion of electrophoretically identical proteins.

The similarity values  $\overline{I}$  (Tables 4.1, 4.2, 4.3 and 5) were used to generate a dendrogram (Fig. 2) according to the unweighted pair) group average clustering method (Ferguson, 1980).

#### Results

The different electromorphs found at the various enzyme loci are presented in Tables 3.1 and 3.2. We have observed considerable

<u>Figure 1</u> GOT-1 Zymogram Intra- and interspecific variability of the enzyme pattern



GOT-1 heterozygote individuals show a 3-banded phenotype

polymorphism at some loci and this polymorphism was found in most taxa where a large number of individuals have been investigated. At each locus only the electromorphs found at the higest frequency are given in Tables 3.1 and 3.2. The rare variants which are not given do not affect the conclusions of the present work. Enzymes which exhibit a low degree of interspecific variation, i.e. which migrate the same distance in the majority of species, are presented in Table 3.1. Enzymes which have greater interspecific variability are shown in Table 3.2. Since the designation of the electromorphs is based on the electrophoretic mobility of the enzymes, it can be seen from Table 3.1 and 3.2 that the relationships obtained from the enzyme pattern agree well with the taxonomic classification obtained with classical systematic methods. Electrophoresis patterns are more similar between congeneric species than between species of different genera. Electrophoretic identity can only be found in some isolated cases between species of different subfamilies. It is of interest that three enzymes (AK-1, AK-2 and GAPDH) are invariant in all taxa investigated.

This correlation between genetic similarity, assessed from enzyme variants and taxonomic classification becomes clearer if the comparison is based on coefficients of genetic similarity rather than the enzyme pattern. These coefficients are listed in Tables 4.1, 4.2 and 4.3 as comparisons between pairs of the taxa of the subfamilies Pierinae, Anthocharinae and Coliadinae, respectively. The subfamily Dismorphinae is not listed, since only one species (Leptidea sinapis) was studied.

Table 3.1 : Electromorphs found at highest frequency in each species.

Enzymes with low interspecific variation

Taxon	AK-1	AK-2	SAPDH	APK	MDH-1	ALD	IPO	ME	нк	G0T-2
A. crataegi	100	100	100	94	100	100	102	100	106	93
P. brassicae	100	100	100	100	100	100	100	100	100	100
P. cheiranthi	100	100	100	100	100	100	110	100	100	100
A. rapae	100	100	100	100	100	100	102	98	100	100
A. manni	100	100	100	100	100	100	102	98	100	100
A. n. napi	100	100	100	100	100	100	102	103	110	100
A. n. bryoniae	100	100	100	100	100	100	102	103	110	10ō
P. daplidice	100	100	100	94	100	100	96	104	100	100
P. callidice	100	100	100	94	89	100	96	100	98	100
E. simplonis	100	100	100	100	100	100	112	100	98	100
E. crameri	100	100	100	100	100	100	112	100	98	100
£. tagis bel.	100	100	-	94	100	-	112	99	103	100
A. cardamines	100	100	100	94	89	100	112	100	104	98
A. euphenoides	100	100	100	100	89	100	112	103	104	98
C. phicomone	100	100	100	94	100	100	103	103	123	95
C. palaeno	100	100	100	94	100	100	103	103	116	95
C. myrmidone	100	100	100	94	100	100	103	103	116	93
C. crocea	100	100	100	94	100	100	103	99	116	97
C. hyale	100	100	100		1100	100	103	99	123	95
C. australia	100	100	100	94	100	100	103	99	116	95
Cat. florella	100	100	100	94	100	100	108	95	112	98
G. rhamni	100	100	100	94	89	85	103	99	106	97
G. cleopatra	100	100	100	94	89	85	103	99	106	92
L. <b>s</b> inapis	100	100	-	100	100	92	-	97	106	85

The averages of similarity coefficients and their standard deviations found between the taxa of the different subfamilies are presented in Table 5 (as indicated in the method section, the calculation of these coefficients is based on the allele frequencies observed, including the minor alleles at polymorphic loci, which are not shown in Tables 3.1 and 3.2).

High similarity coefficients were obtained between taxa which are regarded as closely related from morphological and other data (e.g. between the members of the genus *Colias*). These taxa clearly show less similarity to more distantly related taxa (e.g. comparison of the *Colias* and *Gonepteryx* species). The lowest similarity coefficients are found between members of the different subfamilies.

The similarity coefficients between the Pierinae and Anthocharinae are clearly higher than between these two subfamilies and the members of the Coliadinae and *Leptidea sinapis*, the only species of the Dismorphiinae

Table 3.2 : Electromorphs found at highest frequency in each species.

Enzymes with high interspecific variation

Taxon	MDH-2	6-PGD	FUM	IDH-1	IDH-2	PK	GOT-1	GPT	PGI	PGM
A. crataegi	98	93 100	105	93	90 100	112	98	102	90 96	(111 115
P. brassicae	100	100	100	100	100	100	100	100	100	100
P. cheiranthi	100	93	100	100	100	100	100	100	100	95
A. rapae	90	107	98	95	110	106	88	100	107	100
A. manni	90	100	98	95	100	106	88	100	100	100
A. n. napi	90	100	90	98	100	100	90	115	100	102
A. n. bryoniae	90	100	90	98	100	100	90	115	100	102
P. daplidice	90	100	95	86	97	103	93	130	97	110
P. callidice	90	89	95	91	97	106	130	81	109	108
E. simplonia	102	87	104	78	90	103	103	126	108	90
E. crameri	102	93	104	78	90	103	112	121	108	100
E. tagis bel.	102	87	105	76	90	103	101	94	97	92
A. cardamines	91	92	105	84	97	103	93	118	91	85
A. euphenoides	91	103	105	84	97	103	93	104	82	92 100
C. phicomone	100	79	106	88	102	102	105	81	90	109
C. palaeno	100	79	106	88	102	102	105	88	80	102
C. myrmidone	100	79	106	88	102	100	105	98	98	109
C. crocea	100	79	106	88	102	100	105	88	107	109
C. hyale	95	79	93	88	102	95	105	81	98	109
C. australis	100	79	106	88	102	95	105	81		102 109
Cat. florella	92	79	106	88	108	92	105	81	98	109
G. rhamni	92	79	110	97	142	95	115	89	80	115
G. cleopatra	92	79	110	92	140	95	122	91	80	120
L. sinapis	97	96	97	90	120	115	113	113	114	129

investigated. Leptidea sinapis has the lowest similarity coefficients with all other taxa.

A dendrogram (Fig. 2) has been constructed from the similarity coefficients (Tables 4.1, 4.2, 4.3 and 5), computed from the primary data (Tables 3.1 and 3.2). It showss, more clearly, the grouping of the taxa based on the biochemical-genetic data. The four subfamilies can be recognized as four branchings, however it is remarkable that the Anthocharinae branch from the Pierinae. Branch points of the genera are usually above the level of subfamilies (between 0.36 and 0.59). Colias and Gonepteryx species branch at a higher level of genetic similarity than nongeneric species of the subfamilies Pierinae and Anthocharinae.

#### Discussion

It has become evident from numerous investigations in recent years that electrophoretic techniques provide a very valuable tool for systematisists.

Table 4.1 : Coefficients of genetic similarity (1-values)

between Pierinae-species.

	P. brassicae	P. cheirenthi	A. rapse	A. manni	A. n. napi	A. o. bryoniae	P. daplidice	P. callidice
A. crataegi	.35	.32	.33	.35	.34	.34	.37	.32
P. brassicae		.88	.53	. 64	.56	.57	.42	.32
P. cheiranthi			.52	.58	.51	.51	.37	.32
A. rapas				.90	.51	.56	.43	.38
A. manni					.60	.60	.47	.38
A. n. napi						1.0	.42	.32
A. n. bryoniae							.42	.32
P. daplidice								.55

Table 4.2 : Ī - values between Anthocharinae-species

	t. crameri	t. tagis bell.	A. cardamines	A. euphenoides
E. simplonia	.83	.52	.36	.37
E. crameri		.48	.37	.39
E. tagis bell.			.40	.39
A. cerdamines				.74

The application of these techniques in establishing genetic relatedness, however, appears to be restricted mainly to congeneric species (Ayala et al., 1974; Avise, 1974; Selander and Johnson, 1973), since the range of similarity detectable by enzyme-electrophoresis rapidly decreases beyond the generic level and reaches the critical point where two species have no electrophoretically identical enzymes in common. It is of interest therefore that in the Pieridae it has been possible to clearly establish genetic affinities even in interspecific comparisons of members of different subfamilies. It should be emphasized, however, that the sample of enzymes investigated has some influence on the similarity coefficients,

since rates of divergence are quite different for individual enzymes. It is possible that in this study a rather conservative sample of enzymes has been investigated.

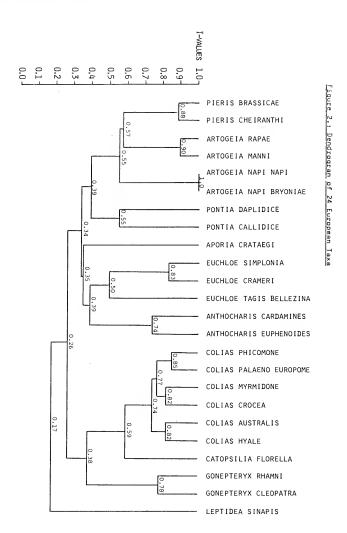
Three enzymes, AK-1, AK-2 and GAPDH, were almost invariant in all Pierid species investigated and were the main, though not exclusive contributors, to the level of genetic identity found in inter-subfamilial comparisons. These three enzymes may prove very valuable for enzymatic characterization of butterfly taxa beyond the generic level, though further work will be necessary to establish this point.

Table 4.3 : I - values between Colladinae-species

	C. palaeno europ	C. myrmidone	C. crocea	C. hyale	C. australis	Cat. florella	G. rhamni	G. cleopatra
C. phicomone	.85	.79	.71	.76	.83	.62	.35	.34
C. palaeno europ.		.79	.77	.63	.79	.53	.35	.35
C. myrmidone			.82	.63	.79	.59	.34	.34
C. crocea				.64	.80	.54	.40	.39
C. hyale					.82	.56	.45	.44
C. australis						.64	.44	.64
Cat. florella							.33	.33
G. rhamni								.78

Table 5 : Mean I-values and standard deviations between the taxa of the different subfamilies

		erent s	OD I BHILL
	Anthocharinae	Coliadinae	Dismorphiinae (L. sinapis)
Pierinae	0.33 ±0.07	0.28 ±0.06	0.22 ±0.03
Anthocharinae		0.25 ±0.04	0.22 <u>+</u> 0.07
Coliadinae			0.17 <u>+</u> 0.03



#### 1. The genetic divergence of the subfamilies

The subfamilies investigated show different degrees of genetic divergence (Table 5). Leptidea sinapis, the only Dismorphiinae in this study, is clearly isolated by the biochemical-genetic criteria as it has the lowest similarity coefficients. The genetic similarity between the Pierinae and Anthocharinae is greater than between these two subfamilies and the Coliadinae. The Anthocharinae may be characterized biochemically as a unit, but their branching point from the Pierini lies at the same level as those between different genera of the Pierini or that between the genera

Gonepteryx and Colias (Fig. 2). Therefore this biochemical data support the decision of Ehrlich (1958) and others to group the Anthocharini and Pierini as tribes of the Pierinae.

The somewhat closer electrophoretic similarity of *Aporia crataegi* to the Anthocharinae than to the Pierinae is probably not significant, but supports the relatively close biochemical-genetic relationship between the two subfamilies.

The isolated position of Leptidea sinapis results from the observation that this species has common electromorphs with other Pieridae only at the AK-1, AK-2, APK and MDH-1 loci which are all highly conservative, i.e. have a low number of electromorphs in the material investigated (see Table 3.1). Lorkovic recently expressed some doubts, based on morphological observations, as to whether Leptidea is really a Pierid (personal communication). It would be of interest to investigate whether the low degree of genetic similarity of Leptidea sinapis is typical for other taxa of the subfamily Dismorphiinae or the genus Leptidea. At the same time, however, the genetic divergence of species of other butterfly families from the Pieridae should be established and compared with the value found for Leptidea sinapis.

### 2. The position of Catopsilia florella F. 1775

There is a remarkable high genetic similarity between Catopsilia florella and species of the genus Colias. This similarity is clearly higher than that between species of Colias and Gonepteryx. Higgins (1975) classified Catopsilia florella as a Pierinae species. The biochemical genetic data support the opinion of most other authors (e.g. Klots, 1931/32), that Catopsilia florella should be included together with the species of the genera Colias and Gonepteryx into the subfamily Coliadinae.

## 3. The division of the genus Pieris Schrank 1801

Verity (1947) and Kudrna (1974) maintain that the genus Pieris Schrank 1801 should be subdivided into two genera, Pieris and Artogeia Verity 1947 respectively. The taxa brassicae and cheiranthi, which were thus isolated in the "new genus Pieris", show the same biochemical-genetic similarity with taxa of the "new genus Artogeia" as is found between Artogeia taxa themselves. Therefore, the electrophoretic data do not support the proposal that the old genus Pieris should be split in two.

Current investigations of additional taxa of this group may clarify the phylogenetic relationships.

## 4. The relationships between the taxa brassicae L. and cheiranthi Hbn. and between the taxa simplonia F. and crameri Btlr.

Unlike sympatric species where reproductive isolation is directly demonstrable, the relationships of allopatric populations is often difficult to determine. *Pieris brassicae* L. and its isolate *P. cheiranthi* Hbn. in the Canary Islands, and *Euchloe crameri* Butler of the Mediterranean region

and its subalpine relative E. simplonia Freyer are examples of such cases. P. cheiranthi was originally described as a new species, but has since been regarded by many authors as a subspecies of P. brassicae (e.g. Higgins, 1975). Others maintain that they are specifically distinct (Kudrna, 1973; Schurian, 1975), Similarly, E. simplonia is often considered as a "glacial" subspecies conspecific with E. crameri, even though many others have assumed them to be good species on the basis of morphological differences. In particular, distinctness of their larvae and pupae is well known (e.g., Catherine, 1920; Verity, 1947; Back, 1979). Neither enzyme analysis nor morphological studies measure reproductive relationships. Nevertheless, the magnitude of genetic divergence between related allopatric forms may provide some insight into such systematic problems when it is compared with data for the sympatric species pairs. The pairs A. rapae and A. mannii, A. cardamines and A. euphenoides, G. rhamni and G. cleopatra, and those of the genus Colias are at least partially sympatric. Some are sibling species. Similarity indices for these pairs range from 0.74 to 0.90. Some of these species have wide distribution ranges, but the genetic divergences in geographically distant populations so far studied are significantly lower than the range given above; for instance, A. rapae from Europe and Japan, or A. cardamines from Europe and Japan have the  $\bar{I}$  value of at least 0.95 (unpublished data). In contrast, the  $\bar{I}$  value of 0.88 for E. crameri and E. simplonia, falls within the range of genetic disparity found for sympatric species pairs. The interspecific genetic similarities of some sibling species may overlap with intersubspecific similarities in Drosophila (Avala et al., 1974). We have not encountered similar cases in butterflies, yet future studies may reveal such situations. With this reservation, therefore, the data suggest specific distinctness of the above allopatric pairs. Rapid genetic drift and establishment of reproductive barriers in island populations or experimental stocks founded from small numbers of individuals have been demonstrated in Drosophila (e.g. Carson, 1968; Templeton, 1980). P. cheiranthi may represent such an example. It would have been extremely interesting if the genetic composition of the newly founded colony of P. brassicae in Chile (Gardiner, 1974) were followed from the beginning and compared with P. cheiranthi and European P. brassicae.

## 5. The napi - bryoniae problem

The taxa napi L. and bryoniae Hbn. have been regarded as: different species (Mueller and Kautz, 1938; Forster and Wohlfahrt, 1976), as semispecies (Lorkovic, 1962) or as subspecies (Higgins, 1975). Bowden (1972) describes the holarctic  $Pieris\ napi$  - bryoniae complex as a "perfect example of a superspecies". The present results on 20 enzyme loci support previous observations (Geiger, 1978) that biochemical-genetic differences between these two taxa are extremely low ( $\bar{\mathbf{I}}$  values between population samples of at least 0.992). The same electromorphs occur in

both taxa, when very infrequent electromorphs are disregarded. The previous observations (Geiger, 1978) that differences between *napi* population samples are sometimes greater than differences between *napi* and (Swiss) *bryoniae*, has been substantiated here with more animals. A specific report on *napi* and *bryoniae* and on some closely related taxa is in preparation.

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# A New *Tortyra* from Cocos Island, Costa Rica (Lepidoptera: Choreutidae)

John B. Heppner

Department of Entomology, Smithsonian Institution, Washington, D.C. 20560

The following new species of *Tortyra* is described here to further document the unique fauna of Cocos Island, off the western coast of Costa Rica. Unlike most of the oceanic islands near the west coast of Central America and northern South America, Cocos Island has a wet tropical forest. The new *Tortyra* is almost certainly an endemic of the island and is here named in honor of Dr. C. L. Hogue of the Los Angeles County Museum of Natural History, who collected the type series.

## Tortyra hoguella Heppner, new species

Size. Forewing length 5.2-6.5 mm.

Head. Dark fuscous with white between antennal bases; from dark fuscous; labial palpus white with dark fuscous apical segment; antenna purple iridescent with white area near apex.

Thorax. Lustrous dark grey; patagia fuscous irrorated with white; venter white; legs banded with dark fuscous. *Forewing*: basal ½ fuscous irrorated with white; mid ½ of wing with a broad brown band, with a silver and green iridescent line along basal part of band and a broad white border, distally irregular; apical ½ of wing fuscous with broad purple iridescent area from tornus almost to apex; ventral side lustrous bronze fuscous; fringe lustrous fuscous. *Hindwing*: uniformly bronze fuscous; ventral side lustrous bronze fuscous; fringe lustrous fuscous.

Abdomen. Dark fuscous; venter white. *Male genitalia*: uncus and gnathos absent; tegumen narrow, broadening dorsally toward extended anal tube resembling a socius; vinculum strong, rounded; anellus triangular; valva oblong, narrowing to sharp extended apical thorn-like point; extensive inwardly directed setal field from dorsal valval margin; aedeagus with phallobase; cornutus a large flat spatula-like shape with a dentaceous apical edge. *Female genitalia*: papilla anales setaceous; posterior apophyses long and slender; anterior apophyses short and very stout; ostium a simple membranous opening on intersegmental membrane posterior to rounded posterior edge of 7th sternite; ductus bursae membranous, long and spiralled, with spirals twisted around bursal appendage near bursa; ductus seminalis from near ostium; bursa copulatrix ovate with elongate appendage; signum a simple spicule band on one side of bursa.

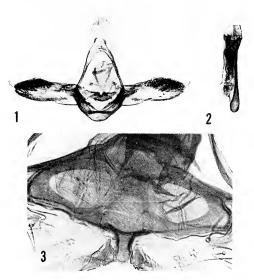


Fig. 1. Tortyra hoguella Heppner, new species, ♂ genitalia (holotype, JBH slide 1383).

Fig. 2. Same, aedeagus (enlarged).

Fig. 3. Anellus (enlarged) (paratype, JBH slide 1541).



Fig. 4.  $Tortyra\ hoguella\ Heppner,\ new\ species,\ \mbox{$\mathbb{Q}$}$  genitalia (paratype, JBH slide 1555), bursa.



Fig. 5. Tortyra hoguella Heppner, new species (& paratype, Cocos Id.).

Holotype &. Wafer Bay, Cocos Id., 17-22 IV 75, C. L. Hogue (LACM). Paratypes. Costa Rica: Cocos Id., 17-22 IV 75, C. L. Hogue (5 &, LACM); Rio Genio, Cocos Id., 17-22 IV 75, C. L. Hogue (1 \, LACM). [Paratypes to BMNH and USNM].\(^1\)

Host. Unknown but probably a species of *Ficus*, as is usual for other *Tortyra* species.

Remarks. Tortyra hoguella has one of the most unusual wing patterns in the genus due to the prominent white forewing fascia. The male genitalia are similar to several species of Tortyra, with some similarity to Tortyra spectabilis (Walker) from Brazil, although the wing maculation is unique. The female genitalia have the ductus bursae spiralled and twisted around a bursal appendage as is typical for the genus and only this portion is illustrated. Most female Tortyra genitalia are almost identical.

LACM = Los Angeles County Museum of Natural History, Los Angeles, California; BMNH = British Musuem (Natural History), London, England; USNM = National Museum of Natural History, Smithsonian Institution, Washington, D.C.

## Troidine Swallowtails (Lepidoptera: Papilionidae) in Southeastern Brazil: Natural History and Foodplant Relationships

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Keith S. Brown, Jr.<sup>1</sup>,<sup>2</sup>, Antoni J. Damman<sup>1</sup> and Paul Feeny<sup>1</sup>

Section of Ecology and Systematics, Division of Biological Sciences, Cornell University, Ithaca, New York, 14853, USA and

<sup>2</sup>Departamento de Zoologia, Instituto de Biologia, Universidade Estadual de Campinas, C. P. 1170, Campinas, São Paulo, BRAZIL 13.100

Abstract. Five species of troidine swallowtails, Parides proneus, P. bunichus, P. agavus, P. anchises nephalion, and Battus polydamas, sympatric in central São Paulo state, southeastern Brazil, differentially utilize the available Aristolochia hostplants. All early stages differ morphologically, with the possible exception of eggs of P. bunichus and P. agavus. In two study sites, the adult populations fluctuated greatly and disharmoniously in approximate two-month cycles. Individuals moved an average of near 100 m and up to 1.3 km between successive recaptures, probably in search of flower resources. Adult lifespans in the field and laboratory averaged less than two weeks, with a majority of field-recaptured individuals passing through one of the six major wing wear classes per week. Laboratory cultures, maintained in a walk-in growth chamber, were used to investigate larval and adult behavior, pupal diapause, oviposition, and hostplant palatability in the five species of butterflies, with relation to the six potential hostplants sympatric in the field.

#### Introduction

Papilionid butterflies in the tribe Troidini have long been known to feed specifically on plants in the genus Aristolochia, and are commonly referred to as Aristolochia swallowtails. (Rothschild & Jördan, 1906; Munroe, 1960; Ehrlich & Raven, 1964). Although homopterans, tingid bugs, cassidine beetles, and larvae of noctuid and pyralid moths have been observed on Aristolochia, relatively few herbivores other than the Aristolochia swallowtails can feed on these plants (D'Araujo e Silva et al., 1968; Rausher, 1979a; K. B., pers. obs.). Aristolochia vines characteristically contain aristolochic acids (nitrophenanthrenes) that have pharmacological effects on vertebrates (Hoehne, 1942: 14-17; von Euw et al., 1968) and strongly inhibit feeding by some insects (Bernays & Chapman, 1977; Rausher, 1979a). The plants also contain several benzylisoquinoline alkaloids, sesquiterpenes, and other secondary components (Fraenkel, 1959; Hegnauer, 1964).

Aristolochia swallowtails sequester some of these secondary chemicals from their hostplants, apparently making the butterflies unpalatable to

many potential predators (von Euw et al., 1968; Rothschild et al., 1970; Rothschild, 1972; R. Nishida, pers. comm.). The butterflies advertise their distastefulness through aposematic coloration, and serve as models in Batesian and Muellerian mimicry complexes (Rothschild & Jordan, 1906; Brower, 1958; Brower & Brower, 1964; Young, 1971a, 1971b).

Because the biology of the troidine swallowtails is linked so closely to that of their *Aristolochia* hostplants, a thorough study of this plant-insect association could provide insights into the evolution of plant defenses, and into the use of plant chemicals by insects. The basic biology of the system has received limited attention until recently. Several studies of the natural history of various North and Central American troidines have appeared in the past decade (Young, 1971a, 1971b, 1972a, 1972b, 1973, 1977, 1979; Muyshondt, 1974; Rausher, 1979a, 1979b; de Vries, 1979). Rausher (1979a) studied the interaction of *Battus philenor* and its two host plants in southeastern Texas. The South American members of the tribe have been studied by Moss (1919), D'Almeida (1922, 1944, 1966), and Cook *et al.* (1971).

In this paper we describe an assemblage of five troidine butterflies sympatric in central São Paulo state (Battus polydamas, Parides proneus, P. bunichus, P. agavus, P. anchises nephalion³), emphasizing the interaction with their Aristolochia hostplants. The natural histories and laboratory culture techniques presented here provide the foundation for planned field and laboratory studies of the biological and chemical aspects of this Troidini-Aristolochia interaction.

## Study Sites and Methods

Wild troidine populations were observed on the grounds of the Horto Florestal de Sumaré, located in the interior of the state of Sao Paulo, Brazil (22°51′S., 47°16′W., 600 m elevation) (Figure 1, A and B). Between October and March (summer), temperatures at Sumare average 23°C; the April to September (winter) average is 18.5°C and daily temperature ranges often exceed 10°C. The bulk of the average annual rainfall of 1300 mm falls during the summer. Because Sumare lies at the intersection of three major climatic domains, the distribution of the annual precipitation is highly variable from year to year (Figure 2).

The Horto Florestal (856 ha, of which 50 were intensively covered in the field work) covers a mosaic of poor, sandy soils and rich soils, originally supporting cerrado scrub and semi-deciduous open forest, respectively. The troidines inhabit riverine tangles and the shady middle and understory beneath an introduced *Eucalyptus* canopy of the semi-deciduous forest (Figure 3). Three species of *Aristolochia*, *A. melastoma*, *A. arcuata*,

The placement of nephalion and other "species" of Rothschild and Jordan (1906) as subspecies of anchises, and the species distributions indicated in Figure 5, follow a biosystematic revision and biogeographical study to be published by K. Brown.

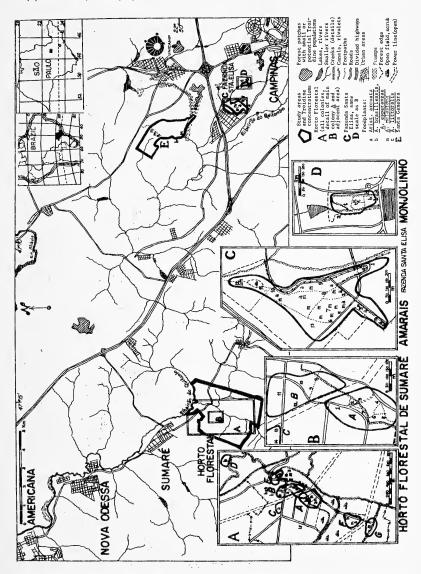


Fig. 1. Map showing study sites for Troidini/Aristolochia interaction in the region of Campinas and Sumare, São Paulo. Small numbers in detailed maps B and C indicate subareas for marking of adults (see Fig. 10).

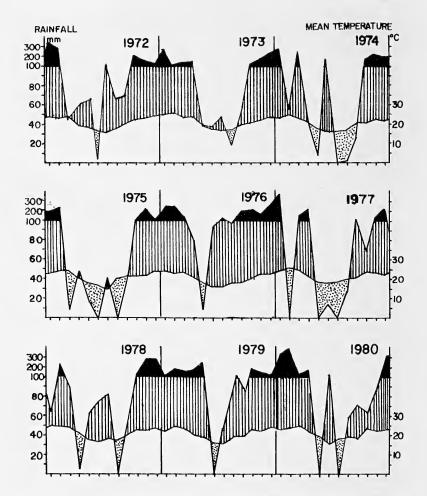


Fig. 2. Monthly and yearly fluctuations in rainfall (mm, scale at left) and temperature (°C, scale at right) in the Horto Florestal de Sumaré, São Paulo Data for 1974-1978 are from Vasconcellos-Neto (1980). Monthly rainfall data for 1972-1973 are from nearby Nova Odessa (see Fig. 1), other years are from within the Horto Florestal. Mean monthly temperature is corrected for altitude difference from data measured in Nova Odessa. Black areas are very humid months; dotted areas, very dry. The maximum yearly rainfall (1887 mm in 1976) immediately followed the minimum yearly rainfall for this decade (1003 in 1975).



Fig. 3. Middle and understory of the *Eucalyptus* semi-deciduous forest in the (upper) Horto Florestal de Sumaré, preferred habitat of the troidines and their *Aristolochia* foodplants. Photo at right by J. Vasconcellos-Neto.

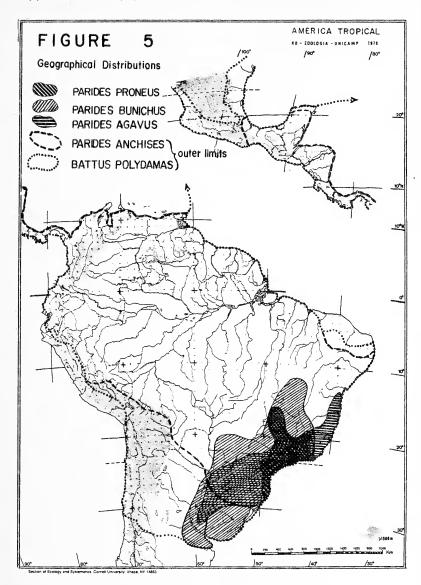
Fig. 4. Aristolochia foodplants of troidines, common in central São Paulo. a (left), (lower) A. melastoma; upper, leaves; lower, flower. b (upper center), A. arcuata, leaf and flower. c (right), A. brasiliensis; upper, leaves; lower, flower. d (lower center), A. littoralis, flowers, leaves and fruit, from Hoehne (1942).

and A. brasiliensis (Figure 4), commonly grow in light gaps, along forest edges, and in mildly disturbed areas within the forest. Two additional species, A. littoralis (Figure 4d) and A. triangularis, occur infrequently in the Horto. A. gigantea, cultivated nearby, represents a sixth potential foodplant for the troidine larvae.

An additional study area near Campinas, São Paulo, is the Fazenda Santa Elisa of the Instituto Agronômico de Campinas. A large troidine concentration occurs in a *Eucalyptus* woodlot similar to the Horto Florestal: Amarais, with abundant *A. melastoma* and *A. arcuata* (Figure 1, C). One km east of Amarais is the 3-ha forest garden Monjolinho (Figure 1, D), with a cool, humid understory beneath native trees; here there are patches of *A. esperanzae* (near *A. brasiliensis*) and *A. littoralis*. A fourth site, visited only occasionally, is a 250-ha woods north of Campinas (Figure 1, E) with small numbers of *A. melastoma*, *A. arcuata*, and *A. brasiliensis* plants in the more open understory and along humid edges of a natural semi-deciduous forest on rich soils. All of the study sites are in the basin of the upper Ribeirão do Quilombo (Figure 1).

The five troidines well established at Sumaré and Campinas have geographic ranges that differ widely (Figure 5³). P. bunichus and P. proneus extend into the cool montane and central plateau regions of eastern and southern Brazil, with the former much more widespread. P. agavus occurs most abundantly in the mild coastal regions of eastern and southern Brazil, but also extends far southward and inland. P. anchises and Battus polydamas are widespread and often prefer warm, dryer climates. At least six additional troidines are known from central São Paulo, including Parides neophilus eurybates which is occasionally encountered in the study sites. Observations throughout the Neotropics suggest that the occurrence of but five or six troidines out of a potential pool of 11 to 16 species at a particular site is a general phenomenon (Moss, 1919; D'Almeida, 1966; K. B., pers. obs.).

Between November 1978 and September 1979, and again after August 1980, one of us (K.B.) spent two to ten hours each week conducting mark-recapture studies of the adults in the Horto Florestal, and observing adult behavior, resource utilization, and oviposition as well as searching for larvae on the foodplants. Parallel studies were undertaken in the two Santa Elisa sites starting in the later part of 1980. Captured adults were sexed, assigned to one of six wing wear classes, numbered on the underside of each hindwing (P. bunichus, P. proneus, P. agavus) or forewing (P. anchises, P. neophilus, Battus polydamas) with an indelible marking pen ("Sharpie", Sanford Corp.), and immediately released (usually within 30 sec). Butterflies were often captured two to six times within a single sampling session (Table 1) and were invariably placed in the same wing wear class all times, attesting to the reproducibility of the wing wear assignments. Rapid return of marked butterflies to pre-capture activities



TROIDINI IN CENTRAL SÃO PAULO - CUMULATIVE RESULTS OF CAPTURES AND RECAPTURES THROUGH MID-1981

TABLE

CAPTURE DATA					TOT	TOTAL NUMBER MARKED	ARKED						WING	S WEA	R CLA	SS (1st (	WING WEAR CLASS (1st CAPTURE)	TURE)	
	Sumaré	ré (;	(200 hours)	Amarais		(87 hours)	Monje	olinho	Monjolinho (45 hours)		Invanilas	TOTAL	( ton-	-		n	1	n	٥
SPECIES	×	[Es	Total	Σ	EE4	Total	Σ	íz.	Total	Eggs	Larvae	ADULTS	eral)	(fresh)	int.)	(int.)	WOLT)	(worn) (ver)	o1d)
Battus polydamas	173	119	292	45	62	107	28	2	30	35	13	429	9	77	91	132	61	43	19
Parides proneus	786	270	756	177	149	326	e	П	7	1	3	1086	11	347	363	228	87	47	3
Parides bunichus bunichus	311	147	458	121	83	204	16	7	20	1	19	682	9	180	202	143	80	58	13
Parides agavus	74	41	115	20	11	31	39	16	55	7	23	201	7	67	48	51	18	7	en
Parides anchises nephalion	53	37	06	14	11	25	7	2	6	11	23	124	3	23	36	37	18	2	2
Parides neophilus eurybates	11	2	13	2	1	3	-	0	1	0	0	17	0	3	7	9	-	0	0
TOTALS:	1108	616	1724	379	317	969	96	25	119	54	81	2539	33	747 769	747	29.7	265	160	05

RECAPTURE DATA (Days after initial capture)

						9.	. 111	23. L	ери	ι.
	12-18 days later 19-25 days later (25-32 days later 532 days barer (62 possible days) (60 possible days) (63 poss.days)	Average	Day	1	0.02	0.02	90.0	ı	1	0.1
	<b>&gt;</b> 32 d (48 pc	Ave	Total	1	1	1	3	1	1	2
1	ater ays)	. JĮ nj	1 ×	1	_		ı	ı	ı	2
	ays la	Average	Day	0.04	0.11	0.08	0.09	1	1	0.3
	ж-32 d 53 ро	Ave	Total		9	7	2	1	1	17
	ter (ays)	1t.		'			0.08 1 -	ı	ı	-
ĺ	s la le d	r Mu	Day 2x		7 4		8 1	2 -	1	9
	day	Average Mult.	Da	0.03	0.37	0.18	0.0	0.02	1	0.7
	19-29 (60 p	Aı	Total	2	22	11	2	1	1	14 1 41 0.7 6 1 17 0.3
	er ys)	Mult.	3x		-	1	1	1	1	F
	lat e da		2x		6	-	7	1	1	14
	days ssibl	Average		0	0.71	0.23	0.21	0.02	1	1.2
	5-11 days later 12-18 days later 19-25 days later Ar-22 days later (79 possible days) (62 possible days) (62 possible days)	A.V.	Total	5	77	14	13	1	1	77
	s) (s	ole 4-	. Š	1	2	1	1 -	1	1	2
į	ater	Multiple	2x 3x	1 1 -	33 4	- 6	10 1		1	9 7
	5-11 days later 79 possible days)							80		~
	11 da poss	Average		0	1.67	0.54	0.38	0.08	1	2.8
	5-(79	Ā	Total	13	132	43	30	9	1	224
	r /s)	Mult.	3x	1	11 4	- 2	-	ı	1	5
	late e da		2x	'			1	1	1	16
	lays ssib1	Average	Day	0.35	3.20	1.00	0.25	0.15	0.05	5.0
	2-4 days later (20 possible days)	Ave	Total	7	99	20	2	3	-	100
	70	5-	9 x	ı	1		1	-	ı	2
į	farke	Multiple 5-	3×		27 6	1	5 1	1	1	_
	as l ible		2x			3 10		ν,		4
	Same Day as Marked (84 possible days)	Average	Day	0.17	2.43	0.83	0.48	0.26	0.02	4.3
İ	Same (84	Av	Total	14	213	70	70	22	2	31 361 4.3 47 7 2 100 5.0 16 5 224 2.8 54 6 2 77 1.2
	ers Jouy	ercc anst		-	12	6	80	-	0	31
	rion tion	cabr obor	14 30	10%	277	24%	202	27%	18%	33%
			TOTAL	43	482	163	101	33	3	825
	****		SPECIES	B. polydamas	P. proneus	P. bunichus	P. agavus	P. anchises nephalion	P. neophilus	TOTALS

Bach numbered butterfly is counted only once per day (even if recaptured several times), but may be counted on different days.

was routinely observed, suggesting relative unimportance of marking trauma.

These studies showed that the Horto Florestal harbored a 6-ha central concentration of troidines (A in Figure 1, A and B) as well as several smaller peripheral concentrations (B-G). Amarais had a single colony covering 25 ha, half of which was heavily overgrown in foodplants (Figure 1, C). Monjolinho showed rather sparse troidines in a few favored lightgaps (Figure 1, D). Populations of troidines were very sparse in the large natural woodlot north of Campinas (Figure 1, E). Troidine concentrations are infrequent within a 20-km radius of the Horto Florestal, the majority of which is dominated by fields, orange groves, and heavily populated area (Figure 1).

Laboratory cultures of butterflies were maintained in a walk-in growth chamber (Figure 6 ab) at Cornell University; stock cultures were also kept in a greenhouse (Figure 6 cd). The environment in the growth chamber approximated summer conditions in the middle and lower levels of the forest at Sumaré. A 13.5 hr "day" period faded into a 10 hr "night" period through programmed dimming of the lights over a 0.5 hr "dusk" period. Temperature alternated between a constant 26°C during the day and a constant 21°C at night. Relative humidity was kept between 85% and 90% throughout the daily cycle, but because of the constant air flow the atmosphere was a drying one. A diffuse, fine-grained, and relatively lowintensity light structure, similar to that of the Horto Florestal middle level (Figure 3), and a dark humid understory, were necessary components for the adaptation of the butterflies in both the growth chamber and the greenhouse (Figure 6). Butterflies visited cut or potted flowers as well as artificial nectar sources (consisting of an orange or vellow scouring sponge in a plastic petri dish filled with 1:6 honey:water solution). The butterflies often preferred to rest and sleep on dacron net curtains hung in the culture areas. Juvenile and adult troidines did not survive as well in the greenhouse as in the growth chamber, perhaps because of daily and seasonal fluctuations in temperature, and predation by ants. In both cultures, however, normal behavior of adults was observed (Figure 6 d-g). Individual larvae could be followed from day to day by marks on their tubercles (fourth and fifth instars) made with various colors of Liquid Paper correction fluid (Liquid Paper Corp.).

## **Description of Juvenile Stages**

The adult stages of most troidines are well known (Rothschild & Jordan, 1906; D'Almeida, 1966); those occurring in the study sites are illustrated in Figure 7. The juvenile stages are less well known, though larvae and pupae of most species have been illustrated or preserved. Variations in the larval characteristics of *Parides anchises*, *P. aeneas* and *P. lysander* (Moss, 1919; Young, 1977; inspection of larvae reared at Cornell University or in the field or preserved in the British Museum (Natural History) by K. B.)

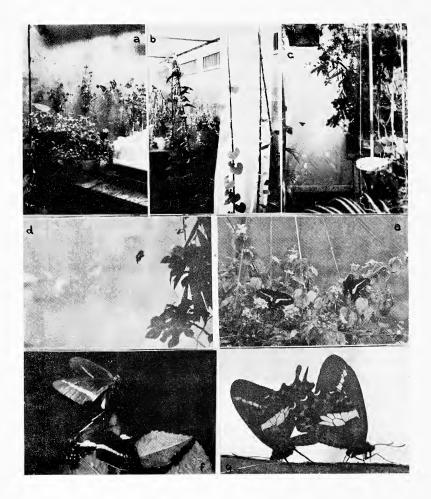


Fig. 6. Laboratory cultures of troidines in Cornell University (except for f). a-b, views of the growth chamber; in a, a P. anchises male is resting on a leaf at upper left, and two P. bunichus are on flowers at the rear, by plastic boxes used for pupal experiments. c-d, views in the greenhouse; in c, a P. bunichus is flying at the rear, and in d, another one is approaching an Impatiens flower. Note the light structure (diffuse in middlestory, dark in understory) in a-c, and Dacron net curtains in b-d. e, a P. bunichus and a P. proneus on Lantana flowers in the growth chamber. f, a courtship of P. bunichus (near Campinas, São Paulo; photo by I. Sazima); note the exposed white scent pouch of the male hindwing over the female antennae. g, a copula of P. bunichus in the greenhouse; both male and female had eclosed from the pupa earlier on the same day.

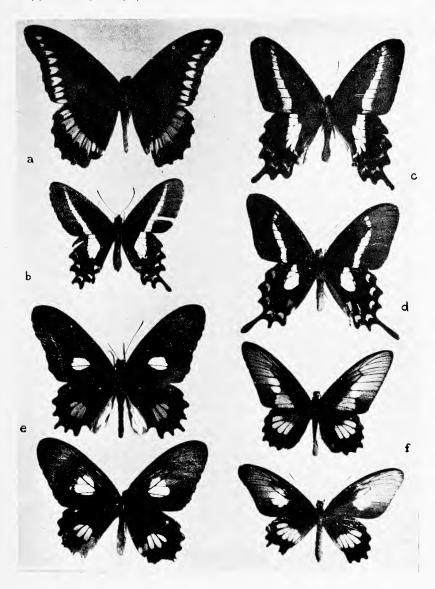


Fig. 7. Adults of troidines captured in the Horto Florestal de Sumaré. a, Battus polydamas, male; b, Parides proneus, female; c, P. bunichuss, male; d, P. agavus, female; e, P. anchises nephalion, male (upper) and female (lower); f, P. neophilus eurybates, male (upper) and female (lower). Note the white or black androconial scales in the male Parides hindwing anal folds (c, and e-f upper).

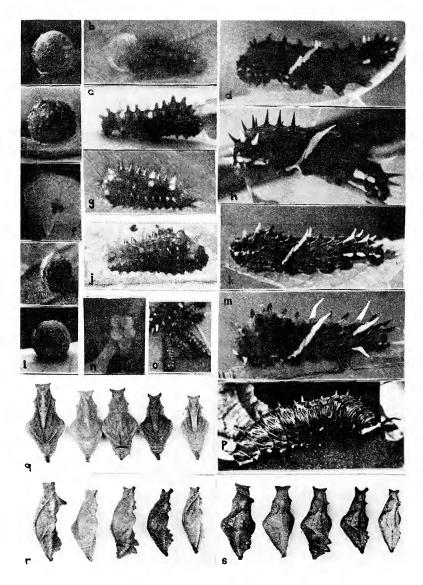


Fig. 8. Juvenile stages of the five resident troidines in the central São Paulo study sites, Eggs (at left) 8.5x (except for f, egg position under leaf, 1.7x; and n, egg cluster, 3.4x); first instars (left center) 7x (except for o, group of larvae, 2.3x); fifth instars (right), 1.1x; pupae (lower), 0.75x. *P. bunichus*, a-d, left center pupae; *P. anchises nephalion*, e-h, center pupae; *P. proneus*, i-k, right pupae; *P. agavus*, l-m, right center pupae; *B. polydamas*, n-p, left pupae. Pupae, q = dorsal, r = dorsolateral, s = ventrolateral.

suggest that larval color patterns may not be geographically homogeneous. Color patterns in *B. polydamas* larvae vary within a population (Moss, 1919). While it is important to briefly describe and distinguish between juvenile stages encountered in central São Paulo, the following larval color descriptions should be extended to geographically distant populations with caution.

Measurements are on organisms from laboratory cultures, which usually but not always gave normal-sized adults. Those with two significant digits to the right of the decimal were made with an ocular micrometer on material preserved in Kahle's fluid; those with only one digit were made with calipers on living organisms.

### Parides bunichus (Huebner, 1822)

Egg (Figure 8 a): irregularly sculptured spheroid, yellow to red,  $\bar{x} = 1.32$  mm in diameter (max. = 1.44 mm, min. = 1.19 mm, n = 89).

First instar larva (Figures 8 bc): reddish, last few abdominal segments light yellow; head capsule 0.79 mm wide (max. = 0.91, min. = 0.71, n = 165). Second instar: head capsule 1.21 mm wide (max. = 1.36, min. = 1.05, n = 75).

Third instar: head capsule 1.6 mm wide (max. = 1.9, min. = 1.4, n = 17). Fourth instar: head capsule 2.6 mm wide (max. = 3.0, min. = 2.4, n = 31). Fifth instar: head capsule 3.8 mm wide (max. = 4.1, min. = 3.3, n = 14). Note non-overlap of the ranges of head capsule widths between instars, permitting unambiguous identification of larval instar.

All four *Parides* larvae share a basic pattern, with a deep maroon to dark brown-black ground color; conical, pointed, often recurved tubercles on all segments; and a light-colored, oblique side stripe from the base of a light-colored dorsolateral tubercle on the 4th abdominal segment across a light-colored subspiracular tubercle on the 3rd abdominal segment to the base of the proleg on the same. Light-colored tubercles are always present on the 7th abdominal segment (dorsolateral and subspiracular), and the 1st (dorsolateral) and 2nd (subspiracular) thoracic segments.

P. bunichus larvae (Figure 8 d) are distinguished by short tubercles (less than one-half head width), with the light-colored zones strong yellow to orange, and have additional light-colored dorsolateral and subspiracular tubercles on the 9th abdominal segment, but not on the 8th.

The characteristic pattern of the light abdominal tubercles (segments 7-9) of this species and the following three can be recognized in most individuals by the late first instar, and permits rapid and unambiguous identification of larvae.

Pupa (Figure 8 qrs, second from left): light brown or green, short cephalic projections, no abdominal flanges, two dorsolateral maroon dots on the 1st abdominal segment.

Parides anchises nephalion (Godart, 1819)

Egg (Figure 8 ef): pinkish-yellow, noticeably lighter in color and larger than that of P. bunichus (diam. = 1.4-1.5 mm).

First instar (Figure 8 g): similar to P. bunichus. Head capsule about 0.8 mm wide (n = 3).

Second instar: head capsule 1.3 mm wide (max. = 1.4, min. = 1.1, n = 20). Third instar: head capsule 1.8 mm wide (max. = 2.0, min. = 1.6, n = 30). Fourth instar: head capsule 2.7 mm wide (max. = 3.0, min. = 2.3, n = 8). Fifth instar: head capsule 4.1 mm wide (max. = 4.9, min. = 3.5, n = 7). Note the larger width of the head capsule in all stages of P. anchises in relation to P. bunichus.

Light colored areas pale yellow; distinguished by additional light dorsolateral and subspiracular tubercles on the 9th abdominal segment, and subspiracular tubercles on the 8th and usually all thoracic segments, producing prominent yellow lateral patches at the front and rear ends of the larva. All tubercles are nearly as long as the head capsule width, and twice as long as those in *P. bunichus*.

Pupa (Figure 8 qrs, center): green and yellow (brown phase not observed in southern Brazilian populations), moderate cephalic projections, long spatulate flanges on 6th and 7th abdominal segments, upper abdomen widely flaring.

According to Moss (1919), the larva of P. neophilus eurybates (Gray, 1852), which should be found occasionally in the study sites, is nearly identical to that of P. anchises nephalion.

Details of head capsule width for each instar are not available for the remaining species, described below.

Parides proneus (Huebner, 1825)

Egg (Figure 8 i): grayish-white and small (diameter  $\cong 1.0$  mm).

First instar (Figure 8 j): very yellowish in the posterior abdominal segments; strongly club-shaped, with an expanded thorax, tapering posteriorly.

Fifth instar (Figure 8 k): distinguished by additional light yellow dorsolateral and subspiracular tubercles on both the 8th and 9th abdominal segments and on the 3rd thoracic segment. Most tubercles short as in *P. bunichus*, but light-colored tubercles twice as long. Ground color strongly striated with light gray.

Pupa (Figure 8 qrs, right): green or light brown and yellow, moderate cephalic projections, short flanges on 5th through 7th abdominal segments.

Parides agavus (Drury, 1782)

Egg (Figure 8 l): usually darker red than that of P. bunichus, but similar in size.

First instar: similar to that of *P. proneus*, likewise rather club-shaped; less yellowed posteriorly.

Fifth instar (Figure 8 m): distinguished by additional light-colored subspiracular tubercles on the 2nd thoracic segment and the 9th abdominal segment, but not the dorsolateral tubercles on the 9th abdominal segment; light-colored abdominal tubercles twice as long as other tubercles. Ground color often mottled with lighter streaks. Somewhat club-shaped as in *P. proneus*.

Pupa (Figure 8 qrs, second from right): long narrow cephalic projections, triangular flanges on 6th and 7th abdominal segments, red antenna cases, otherwise green or beige strongly mottled with yellow.

Battus polydamas (Linnaeus, 1758)

Egg (Figure 8 n): relatively smooth and small (diameter = 1.0 mm), and deposited in clusters (unlike *Parides* eggs which are always laid singly), usually 2 to 9.

First instar (Figure 8 o): yellow, turning to brown with lighter tubercles after one or two days.

Second to fourth instars: tending to dark red or brown with subequal wirelike tubercles, lighter on the 2nd thoracic and fourth and seventh abdominal segments, thus at times superficially similar to some *Parides* larvae, especially in earlier instars.

Fifth instar (Figure 8 p): wire-like subequal tubercles on all segments, except for dorsolateral tubercles on first thoracic segment and subspiracular tubercles on 2nd (usually) and 7th abdominal segments which are much longer (from the second instar, permitting unambiguous identification). Body maroon, grey, or beige in various proportions, striated with lighter or darker markings, especially late in the instar.

Tubercles the same color as body or lighter, occasionally bicolored. Pupa (Figure 8 qrs, left): green or light brown and yellow, with a long spatulate dorsal process on the thorax (present in all *Battus*, never seen in *Parides*; Moss, 1919).

## Adult Biology

In the laboratory, adults of all species eclosed in the morning (see also Moss, 1919), and were actively flying by midday and for one to two weeks thereafter. In the field, butterflies were rarely recaptured more than two weeks after marking, and consistently passed through one of the six major wing wear classes per week (Table 1, Figure 9). A maximum of 35 days between first marking and last recapture was recorded for a male of P. proneus and a male of P. bunichus; two males of P. agavus lasted 49 and 56 days in Monjolinho, a cool, humid and protective environment with abundant adult resources in the understroy. In the growth chamber, lifespans of P. bunichus averaged 11.4 days (max. 24 days, n = 47), in general agreement with the field data. These results approximate those obtained for troidines in Trinidad forests by Cook et al. (1971) and in Texas thickets by Rausher (1979a), but contrast markedly with the 2 to 7

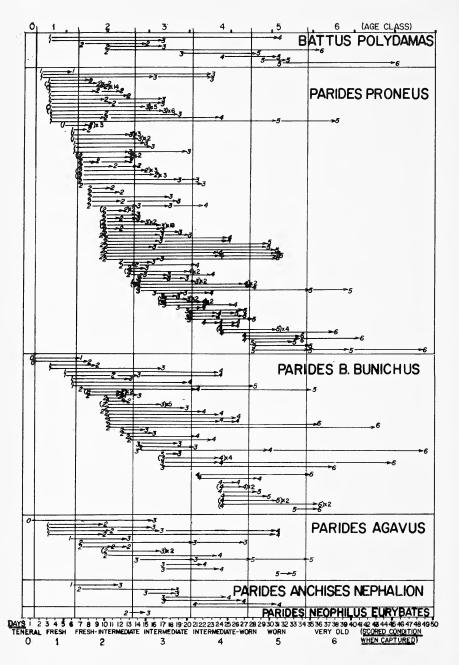


Fig. 9. Aging of recaptured troidines, combined field sites (1980): test of the hypothesis of passage through one of the six wing wear classes each week. Recapture lines for individually numbered butterflies always start within the scored wear class at first marking. Of 61 butterflies which should be in class 2 (fresh-intermediate) when recaptured, 53 in fact were, with 1 in class 1 and 7 in class 3. For recaptures in the other classes of wing wear, 3 shows 89 in 3, 9 in 2, and 3 in 4; 4 shows 44 in 4, 10 in 3, and 3 in 5; 5 shows 20 in 5, 8 in 4, and 3 in 6; and 6 shows 13 in 6 and 9 in 5. Maximum inferred lifespan was 49 days in two separate cases. Note that butterflies were placed at various points within their wing wear class as scored on first capture, in accord with recapture data. If all individuals are placed only on the midpoint of their wing-wear class upon first recapture, and seven days are allotted to each class (except for teneral = 1 day and fresh = 6 days), the numbers found in each recapture set, including all data through early August 1981, are as follows:

Predicted Class	Total Number			und in Ea Scored l		-	
upon Recapture	of Recaptures	1	2	3	4	5	6
1	3	3					
2	101	$\frac{\overline{4}}{4}$	71	26			
3	139		21	107	11		
4	91			25	59	7	
5	67			3	21	$\frac{36}{20}$	7
6	42				3	$\overline{20}$	19
	443						

It may be noted that aging is somewhat accelerated (with relation to the hypothesis) in the earlier wing wear classes, and somewhat retarded in the three later classes, but the overall picture is very coherent.

month lifespans reported by Young (1971a, 1971b, 1972a, 1972b) for wild and captive adults in Costa Rica.

The mark-recapture studies indicated that butterflies rarely moved between the main colony of the Horto Florestal (A in Figure 1 AB) and the outlying concentrations, but often moved around all parts of Area A (Figure 10). In 1980, males captured in the Horto Florestal colony A moved an average of 81 m and a maximum of 660 m between successive captures on the same day (n = 158), or 116 m (average) and 970 m (maximum) on different days (n = 135) (distances were represented by minimum straight-line paths between epicenters of marking areas; see Figures 1 and 10). Corresponding values for females were very similar: 77 m (average) and 620 m (maximum) for the same day (n = 55), and 110 m and 490 m for different days (n = 30). Some evidence for dispersal over several hundred meters or across major barriers emerged from the data, especially in periods of sparse or ephemeral adult resources. Between colony recaptures (A to B or E) numbered only 31 in the total of 825 recaptures, however (Table 1, Figure 10). The occasional appearance in

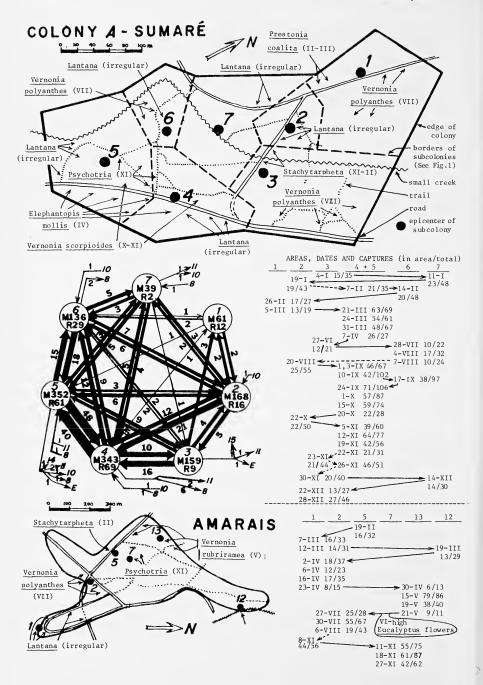


Fig. 10. Movement of adult troidines, and relationship of population concentrations with seasonal nectar sources in Colony A of the Horto Florestal de Sumare (above) and in the Amarais woods (below) (see Figure 11). Locations of preferred flowers, which attracted exceptional densities of Troidines, are indicated on the base maps of each area, along with the epicenters for captures in each subcolony (dark circles). At left center is a summary of all marks and recaptures in the Horto Colony A (as a schematized heptagon), by subcolony (circles at apices); M = total number marked in the subcolony, R = total number of first subsequent recaptures, and numbers by each arrow = first subsequent recaptures in other subcolonies; external arrows = subsequent recaptures or prior captures outside Colony A, representing intercolony transfers. At right are graphs showing movements of populations between different subcolonies throughout the year (Horto Colony A above, Amarais below), giving respective dates, number of captures in the indicated subcolony, and total number of captures for that date; for example, on March 31, 1981, 48 of the 67 troidines captured in Horto Colony A were on Elephantopis flowers in subcoloies 4-5; on February 19, 1981, half of the 32 troidines captured in Amarais were on Stachytarpheta flowers in subcolony 5. All subcolonies were always covered in each day's sampling, usually several times, but more time was spent in areas where more butterflies were encountered. Dotted arrows indicate discontinuities (different years of observation; refer to Figure 11).

the Horto Florestal of *P. neophilus eurybates*, apparently not a resident there, suggests that immigration and emigration of the resident species could occur, in spite of the unfavorable habitat extending on all sides of the site (Figure 1). In support of this, a male *P. agavus* marked in the riverside thicket *D* (Figure 1A) was captured a week later within the Horto Florestal colony *E*, one km to the SW. In the more continuous habitat of the Amarais forest (Figure 1C), individual movements of over 400 m between the scattered flower patches were more frequently recorded (23% of all recaptures). One *agavus* male flew from Amarais to Monjolinho (about 1.3 km) in an hour and a half; a female *bunichus* was also captured in Monjolinho two weeks after being marked in Amarais; and a female *agavus* and a male *proneus* marked in Monjolinho were captured in Amarais, 7 and 32 days later, respectively.

The short life spans of the adults precluded the use of standard methods (Jolly-Seber, Lincoln-Bailey, Manly-Parr) for estimation of population sizes from weekly samples; most butterflies were not recaptured, and very few were recaptured twice (Figure 9). When several samples were made at 2-day intervals, a simple Lincoln analysis suggested that about a third of the *P. proneus* population, a fourth of the *P. bunichus* population, and a tenth of the *B. polydamas* population of Horto Florestal colony *A* was being marked or sampled in a 4-hr standardized intensive capture period (other species gave less than five recaptures). In Figure 11, all samples are

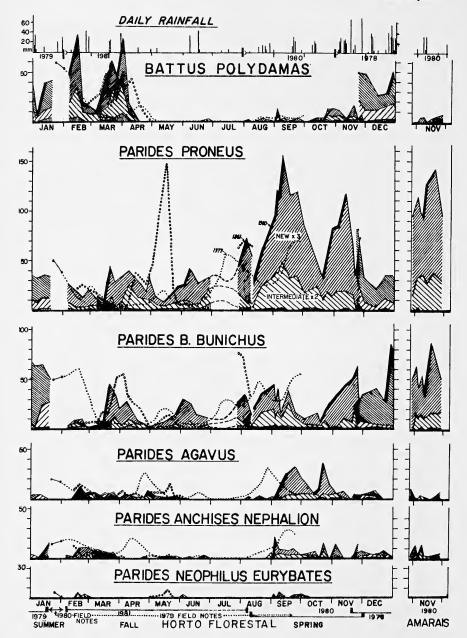


Fig. 11. Variation during the year in relative abundance of troidines in the main colony A of the Horto Florestal de Sumaré, from field data, 1978-1981. All numbers are adjusted to a four-hour sampling period. The daily data have been exaggerated to better define brood emergences - fresh individuals (wear classes 0-2) are given triple their value, intermediate ones (wear classes 3-4) double. Dotted lines are based on numbers seen or captured in weekly visits outside the disciplined mark-recapture periods. Data from Amarais, November 1980 is presented at right for comparison; uppermost curves for Amarais populations are also shown as chains of open circles on the Horto graph, for February to August 1981. Note non-successive broods (less than two months interval) in B. polydamas, P. bunichus, P. agavus, and P. a. nephalion; non-overlap of 1978 and 1980 (November), 1979-1981 (February through early August), and 1979 and 1980 (August and September) data; and desynchronized broods of P. agavus and P. a. nephalion in relation to the commoner species.

corrected to 4 hr, and more weight is given to younger age classes in daily samples; in this way, a very approximate picture of brood emergences and monthly and yearly population fluctuations can be obtained.

Concentrations of butterflies were invariably encountered on the most abundant flower resources within the colony areas (see Figure 10). Adults fed exclusively on nectar, in the field and in the laboratory. Pollen feeding (cf. de Vries, 1979) was not observed in central São Paulo or in any other parts of the Neotropics. "Puddling", common in the Graphium mimics of troidines and thus often reported for this tribe, has only been observed occasionally for Battus, never for Parides. In the Horto Florestal and Amarais, butterflies visited Lantana camara L. and L. lilacina Desf. (Verbenaceae) flowers throughout the year. Seasonal nectar sources included Petrea racemosa Nees et Mart. (late winter) and Stachytarpheta polyura Schau. (spring and summer) (also Verbenaceae), Psychotria and Palicourea species in late spring (Rubiaceae), Vochysia tucanorum Mart. (Vochysiaceae) and Prestonia coalita (Vell.) Woods. (Apocynaceae) in late summer, and Vernonia rubriramea Mart., V. scorpioides Pers., and other composites in the fall and winter. The principal nectar source in Monjolinho was introduced *Impatiens* (Balsaminaceae), abundant in the understory, supplemented by Lantana, Ixora, Euphorbia, and other ornamental flowers in the adjacent sunny garden (exclusive habitat for B. polydamas). When nectar sources dwindled in number, especially in fall and winter, butterflies were recaptured far from their marking localities, and males became increasingly protective of the flower patches, attempting to expel other males which appeared near them. Males often courted the females near the flower concentrations. During courtship, males hovered over females, occasionally darting to and fro, and appearing to brush the white androconial scales on the dorsal surface of the anal fold of the hindwing against the antennae and head of the female (Figure 6 f).

2principally on flowers

TABLE 2
### THAILS 1    TABLE 1
### TABLE 2  THOUSE OF OVIPOSITION SITES BY THE TROIDINES RESIDENT    Aristolochia Species used   Aristolochia Species used
### Trians Resident Record Resident Record Resident Resid
### TABLE 2  THOUSE OF OVIPOSITION SITES BY THE TROIDINES RESIDENT    Aristolochia Species used   Aristolochia Species used
100 100
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 $^{1}$ Plants and insects are in probable evolutionary progression (more advanced to right or below). (Hoehne, 1942; Borwn, in prep.)  $^{2}$  x = oviposits frequently, (x) = oviposits occasionally, o = does not oviposit, ? = unknown.

comparison of the responses of troidine larvae to different aristolochia species in the pield and under laboratory conditions  $^{\rm I}$ 

PABLE 3

Sutterfly Species	melastoma field la	lab Tab	arcuata field L	lta lab	triangu field	laris	triangularis brasiliensis field lab field lab	lab	littor field	ittoralis ield lab	gigar	jigantea leld lab
Sattus polydamas	8	×	٣	×	۲۰	×	2	×	ю	×	35	×
Parides proneus	ю	×	п	×	۰٠	×	0	0	1	C+	٥.	0
P. bunichus	е	×	٣	×	٥٠	×	o	(x)	2	×	<b>٠</b> ٠	0
agavus	2	×	2	×	٠.	×	٥.	٥.	2	×	٥.	×
a. nephalion	е	×	m	×	٠.	×	2	×	1	(×).	٥.	0

Laboratory observations indicated that both males and females could mate on the day of eclosion (Figure 6 g). Virgin females up to two weeks old could mate and subsequently laid fertile eggs; before mating, females very rarely laid (infertile) eggs. The female copulatory pore is internally plugged by sclerotic bars after mating, so multiple matings are very unlikely.

When all captures and recaptures (3571 to mid-1981; Table 1) were plotted by species and sex against half-hour time intervals from sunrise to sunset, females of all *Parides* species were seen to predominate over males in the earliest and latest hours of the day, while the opposite was true for *Battus* (females flew mostly near midday). *Parides proneus* was active significantly earlier in the day than the other species (peaking from 9-10 AM; *polydamas* peaked near 11 and the other *Parides* species showed near-constant activity from 10 AM to 2:30 PM).

## Oviposition and Larval Biology

Parides females deposited eggs singly, usually on the underside of leaves (Figure 8 f). Battus, on the other hand, placed eggs in small clusters on the growing tips of the Aristolochia vines (Figure 8 n). Females of all five species preferred some species of Aristolochia over others when choosing oviposition sites, possibly using chemical cues to identify the preferred species (Table 2). Prior to oviposition the females appeared to inspect the vines visually before "drumming" the leaf surface with their foretarsi. The selection of suitable oviposition sites in the field seemed to depend, also, on the habitat in which the Aristolochias grew; P. anchises nephalion often oviposited in drier portions of the Horto Florestal (C and F, Figure 1A), while Battus polydamas appeared to prefer open habitats (see also Rausher, 1979b) and P. proneus invariably favored low plants, essentially always A. melastoma, in dense undergrowth.

Observations of *P. bunichus* in the growth chamber indicated that females deposited about 20 eggs per day and could continue to produce eggs for up to ten days following the first oviposition. *Parides* females did not oviposit as exclusively on apical leaves as did *Battus* females. *A. littoralis*, *A. gigantea*, and *A. arcuata* leaves often formed necrotic zones where the egg contacted the leaf, similar to that illustrated under a *Parides photinus* egg by Ross (1964). These areas occasionally fell from the leaf, taking the egg with them.

Eggs of Parides had an irregular, hard coating deposited on them by the female at the time of oviposition. This coating was poorly developed in B. polydamas. Five to eight days after oviposition the larvae hatched, eating the egg shell and its coating. Young (1973) proposed that such coatings contained chemicals that protected the egg. Moss (1919) and L. E. Gilbert (pers. comm. to K. B.) suggested that the coating might contain energy rich nutrients to fuel the newly hatched larvae as they sought out the tender apical leaves on which they prefer to feed. By the late second, or early third instar, the larvae could move onto older, tougher leaves. The solitary habit of Parides larvae, coupled with their tendency to eat any unhatched eggs and attack smaller larvae that they encountered, limited the damage inflicted on a plant. B. polydamas larvae were gregarious, displaying no cannibalistic tendencies, and remained several to a plant even after the third instar. Consequently, they did much damage to the Aristolochia plant under attack (cf. Moss, 1919). All mature Aristolochias except A. melastoma, which had little storage root, quickly sent out new shoots when eaten back to the ground, so that defoliation was generally not fatal to the plant. Seedlings and small plants, however, might be killed more easily by extensive herbivory (Rausher and Feeny, 1980).

#### Larvae-Aristolochia Interactions

The laboratory studies showed that larvae of all five species could develop in 20 to 30 days, agreeing with reports of Moss (1919) and Young

(1971a, 1973, 1977) for various species of Battus and Parides. Developmental rates of the larvae depended greatly on the species of Aristolochia on which they fed (Table 3). Most larvae developed rapidly on A. arcuata and A. melastoma, and poorly on A. brasiliensis and A. gigantea. A. littoralis seemed to be of intermediate quality (see also Young, 1973). P. proneus larvae seemed to be the most specialized, growing rapidly only on A. melastoma, while B. polydamas could eat and develop well on most Aristolochias available to it. P. anchises nephalion survived better on A. brasiliensis (which it uses in the field in Sumaré) than the other butterfly species, and P. agavus seemed the best adapted to A. littoralis (and even A. gigantea). The patterns of hostplant palatability roughly paralleled patterns of preference for oviposition site (Table 2), and helped to explain the near absence of P. proneus and the predominance of P. agavus in Monjolinho (Table 1).

In the field, larvae occurred on a limited subset of the palatable Aristolochia species available to them (Table 3). The limited use of some food plants that would support larval growth could have resulted from the inability of females to locate or recognize these plants in the field, from unsuitable microclimatic conditions on these plant species linked to differences in the sites in which the Aristolochias grew, or from physical or biological conditions external to the troidine-Aristolochia system that influence hostplant palatability.

## **Pupal Biology**

The larvae entered a wandering stage prior to pupation. Even at high hostplant densities, such as those in the growth chamber, larvae frequently selected pupation sites other than Aristolochia plants. Butterflies normally eclosed after 13 to 17 days as pupae. Many P. bunichus, and some P. proneus and P. agavus larvae that developed in the drying atmosphere of the growth chamber went into diapause as pupae. P. anchises and B. polydamas never entered diapause under these conditions. Diapause in P. bunichus lasted up to 115 days, and was characterized by a loss of 0.05% to 0.5% of total pupal weight per day compared to a loss of 1% to 3% of total pupal weight per day in non-diapause pupae. Most diapausing bunichus pupae broke diapause within two weeks of transferral to closed plastic boxes lined with moist paper toweling, suggesting that humidity plays an important role in diapause control in this species. D'Almeida (1966) reported that B. polydamas, P. anchises nephalion, P. agavus, and many other species in Rio de Janeiro usually skipped winter generations. Perhaps in these species, diapause is cold-induced.

Pupal diapause would enable butterflies to escape the unfavorable weather and limited flower abundance of cold or dry winters, factors that appeared to influence the phenology of the troidines at Sumaré (Figure 11). All five troidines were present in the spring and summer, when as many as 250 individuals could be seen in a single day. Some staggering of

brood emergences was verified in this period, perhaps related to the shared foodplants (Tables 2 and 3), the short adult lifespan (Figure 9), the long juvenile development time, and varying responses of diapausing pupae to rainy spells (Figure 11). Only *P. bunichus* and *P. proneus* persisted through the winter months, though both were scarce at times from March to May (Figure 11), when *P. agavus* and *P. anchises nephalion* were more frequent. *B. polydamas* was nearly absent during the cooler half of the year, and increased very slowly in the dry spring of 1980 (Figure 11). D'Almeida (1966) observed that troidines occurring together in the vicinity of Rio de Janeiro had staggered peaks of emergence. Foodplant phenology may also influence the feeding patterns of the troidines. *A. arcuata* and *A. melastoma* initiate most of their new growth in winter when most butterfly populations are at a low ebb (Figure 11).

### **Concluding Comments**

Several interactions may define the relationship of Parides and Battus to their Aristolochia hostplants in southeastern Brazil. The chemistry of the Aristolochias could act to influence the patterns of damage by the troidines, and also to allow the troidines to identify some of them as suitable hostplants. Disproportionate levels of parasitism and predation on any of the Aristolochias could reduce larval survival on those plants, even were the plants to be intrinsically suitable as food. The spectrum of Aristolochias used by a troidine species might be limited by competition with other troidines. The physical environment could restrict the Aristolochias available to a troidine on a spatial or seasonal basis. The evolutionary history of each of the five species could influence the pattern of hostplant utilization directly by limiting the hostplant characteristics to which they have adjusted and indirectly by limiting environments in which each troidine can survive.

The larvae of the five troidines at Sumaré did not grow equally well on all the Aristolochias available to them when reared under identical conditions in the laboratory (Table 3). Similarly, the females would not oviposit equally on the six available Aristolochias (Table 2). In both cases plant chemistry is implicated. Not all Aristolochias that supported growth of the larvae of a troidine species were used by that butterfly in the field, however, indicating that plant chemistry is not the only factor in play. Because of the seasonal variation in the abundance of the swallowtail species and in the phenology of growth in some of the Aristolochias, the presence of tender foliage suitable for consumption by first instar larvae on an Aristolochia that was otherwise palatable did not always coincide with the population maxima of a particular butterfly. Only P. bunichus and P. proneus occurred in numbers during the cool winter; these two species range into the cooler montane regions, whereas the other three butterflies range into milder areas. In this way both the physical environment and the

evolutionary history of the troidines could limit the availability of some Aristolochias to the larvae. Parasitism and predation of larvae occurred most frequently on older leaves and on less acceptable foodplants; food quality may thus affect survival of the larvae indirectly. Competition has not been demonstrated, and indeed there is a large excess of foodplant present in Amarais and in parts of the Horto Florestal (colony A) during much of the year; the destructive feeding of B. polydamas larvae, however, could very well decimate smaller patches of foodplant and even affect larvae of Parides feeding on the same plant. Detailed experimental work on this and similar systems is necessary to answer the many questions posed by the troidine-Aristolochia interaction.

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# Karyology of Three Indian Lasiocampid Moths (Lepidoptera)

P. K. Mohanty and B. Nayak

Department of Zoology, B. J. B. College, Bhubaneswar, Orissa, India

Abstract. Chromosome studies on three species of Lasicocampid moths (Crinocraspida torrida, Dendrolinus hyrtaca and Taragama siva) revealed n of 26, 31 and 31, respectively. In both size and morphology, the chromosomes were almost identical. Sex chromosomes, if any, remained unidentifiable. The details of chromosome morphology and behaviour during meiosis are discussed.

#### Introduction

The Lepidoptera constitute a major group of insects of over 200,000 species. Only a small number of these have been cytologically investigated so far. Most studies have been concerned with the chromosomes of Macrolepidoptera, particularly butterflies. The Microlepidoptera are moths which comprise the majority of species, but have been little studied. To date very little work has been done on Indian species of Lepdioptera (Gupta, 1964; Rishi, 1973, 1975; Nayak, 1975). Of the family Lasiocampidae, chromosome counts of only four species have so far been reported (Rishi, 1973; Nayak, 1975). The present paper deals with the chromosome studies of three species of Lasiocampid moths, two being reported for the first time.

#### **Materials and Methods**

The larvae were collected from their respective host plants (see Table 1) and reared in cages. Testes of late larvae (5th instar) and early pupae were found suitable for cytological preparations. Freshly dissected testes were fixed in aceto-alcohol (3:1) overnight and smears were made on prewarmed albuminised slides using 45% acetic acid. The stain used was Heidenhains' Iron Haematoxylin.

#### Observations and Discussion

Crinocraspida torrida: 2n=52. The spermatogonial metaphase chromosomes were exceedingly small, homomorphic and spherical, and were not differentiable into autosomes and sex-chromosomes. The early meiotic stages were ill-defined due to the diffuse nature of the chromosomes. At pachytene, they formed shorter and thicker bivalents though still not countable. At Diplotene, diakinesis revealed chiasma bearing forms like

1 # 8 W

Table 1
Collection Data for Study Material

Name of Species	Food Plant	Place of Collection	Period of Collection
			- X -
Crinocraspida torrida Moore	Terminalia sp.	Bhubaneswar	Dec., 1976
Dendrolinus hyrtaca Cramer	Zizyphus jujuba	Bhubaneswar	Aug., 1976
Taragama siva Lef.	Eugenia jambolana	Bhubaneswar	SeptOct., 1975

'cross', 'V', rod- and dumb-bell-shaped bivalents, many of the chiasmata being terminal or near terminal. Metaphase I cells invariably showed 26 bivalents. The chromosomes were oval in polar view and dumb-bell-shaped on an equatorial plane. A few polyploid cells with almost double the number of metaphase I bivalents were also observed. Metaphase II showed 26 univalents.

Dendrolinus hyrtaca: 2n=62. Metaphase I cells showed 31 bivalents. In some plates, however, one of the bivalents appeared to be deeply stained while in two other plates almost all the bivalents had undergone early resolution, the partners of each bivalent lying in close proximity to each other without any actual contact. In a good number of plates, twice the number of normal bivalents were encountered. At anaphase I, a pair of small deeply stained equal-sized bodies were visible on equatorial region of the spindle when all others had already reached their respective poles. Metaphase II showed 31 univalents.

Taragama siva: 2n=62. Metaphase I cells showed 31 bivalents. Variation in number by one more or one less was marked in a number of cells. This might be due to precocious separation of the partners of a bivalent or fusion of two bivalents. In some abnormal metaphase I cells, many univalent chromosomes were observed along with some bivalents. The univalents lay a little apart from each other but in homologous pairs. This configuration much before onset of anaphase I must have been due to non-pairing or weak pairing of homologues. In anaphase I, the majority of dividing cells showed homologues of one bivalent to trail behind the rest during their anaphasic movement towards the respective poles. Such lagging behaviour even could be followed up to telophase. Metaphase II showed 31 univalents, confirming the haploid complement for this species.

Of the three species chromosomally examined during this study, two of them, D. hyrtaca and T. siva, have a base number n=31 which is in close correspondence with the modal haploid number of the family Lasiocampidae

and with that of Lepidoptera in general (Kernewitz, 1915; Beliajeff, 1930; Saitoh, 1970; Robinson, 1971; White, 1973; Ennis, 1976). The third species, C. torrida, has a haploid number n=26 which is quite different from the modal number. Twelve members of the twenty species of this family which have been cytologically examined so far have the haploid number 31. The occurrence of low haploid numbers like 28 in Trichiura crataegi (Federly, 1945), 26 in Trabla vishnu (Nayak, 1975), 25 in Malacosoma indica (Rishi, 1973) and 26 in C. torrida (present report) indicate a trend towards evolution of lower chromosome numbers, and chromosomal fusion rather than dissociation appears to have played the main role in the process. The lagging anaphasic movement of a pair of elements in Dendrolinus hyrtaca and Taragama siva, perhaps the homologues of a bivalent, points to their sex-chromosome (XX pair) nature.

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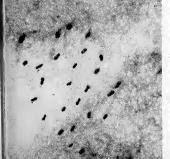
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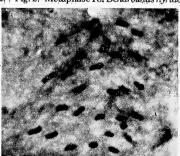
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g. 1. Metaphase I of Crinocraspida torrida; Fig. 2. Metaphase I of Dendrolinus hyrtaca. Fig. 3. Metaphase I of Taragama siva.







## Illustrations and Descriptions of some Species of Pyrrhopyginae from Costa Rica, Panama and Colombia (Hesperiidae)

S. S. Nicolay and G. B. Small, Jr.

1500 Wakefield Drive, Virginia Beach, VA and PSC Box 2510, APO Miami, FL 34002

About eleven years ago, the authors (1969) described a new subspecies of *Pyrrhopyge creon* Druce from Panama' and remarked that it was not possible to make a definite statement about the distribution of the species as a whole. In the intervening years, the junior author has observed and collected *creon* in a number of different localities in Panama' and Costa Rica with some unexpected results. It is the purpose of this paper to bring our knowledge of this interesting species up-to-date.

Nominate creon is distributed continuously from Northern Costa Rica to Cocle' Province, Panama' along both the Atlantic and Pacific slopes of the series of cordilleras forming the continental divide. The axis of this divide runs generally in a northwest to southeast direction. More specifically, the northwesternmost locality at which creon creon has been collected is Guanacaste Province, Costa Rica, from which it is distributed in a general southeastward direction through the Cordillera Central and the Cordillera Talamanca, the last of which enters Panama' in western Chiriqui' province. The continental divide then continues in an easterly direction as the Cordillera of Tabasara', which terminates slightly northwest of the town of Penonome', Cocle' Province. The southeasternmost record is from near the town of El Cope', Cocle', virtually at the terminus of this cordillera. The Atlantic slope has a year-round wet climate and here the butterfly is found from an elevation of 750 m up to 2000 m. Most of the Pacific slope has a pronounced dry season from December to April, and in these areas it seems to be found only above 1000 m. However, the Pacific slope of the Cordillera Tabasara' has the same climate as the Atlantic slope, and here creon can be found again as low as 750 m.

Throughout this range of more than 400 kms. in length, there is continuous highland with elevations greater than 750 m. However, there are two distinct regions, in each case separated by less than 40 kms. from the main range, where the species has developed striking and distinctive subspecies. In each case there is an intervening area of lower elevation

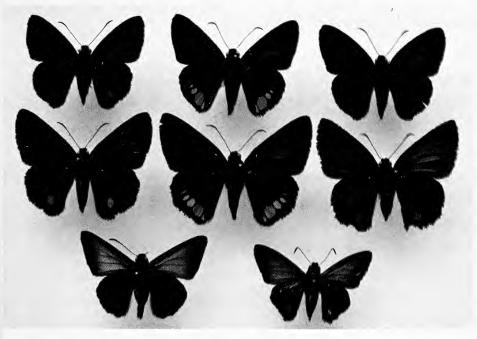


Fig. 1. Upper row, left to right: (A) Pyrrhopyge creon taylori Nicolay & Small of holotype, (B) Pyrrhopyge creon lilliana Nicolay Small of paratype, (C) Pyrrhopyge creon Druce of Middle row, left to right: (D) Pyrrhopyge creon taylori Nicolay & Small of allotype, (E) Pyrrhopyge creon lilliana Nicolay & Small of paratype, (F) Pyrrhopyge creon Druce of Bottom row, left to right: (G) Mimoniades aerata Godman & Salvin of, (H) Pyrrhopyge sangaris Skinner of.

which apparently serves to keep their populations isolated. In neither case have any specimens that could be called intergrades or hybrids with typical *creon* been found.

The first of these regions is an isolated massif with elevations from 750 m to 1000 m of little more than 30 kms. in length located in extreme eastern Cocle' Province and extreme western Panama' Province. This includes the well known collecting localities of Cerro Campana and La Mesa (north of El Valle). It lies about 40 kms. to the east of the eastern terminus of the Cordillera of Tabasara', and is separated from the latter by a low lying area of less than 500 m. The climate here is not as wet as in the Cordillera of Tabasara', and in the months of December to April there is little precipitation, although the forest remains evergreen due to frequent mists and cloud cover. Here occurs the very distinctive subspecies lilliana as described by the authors in 1969.

The isthmus of Panama' then turns northeastward and altitudes of 750 m and over are not encountered again until the region of the watershed of the Chagres River, about 80 kms. to the northeast. Despite intensive collecting in this region, there has been no sign of *creon* either here or further east toward Colombia.

The second region lies in southeastern Costa Rica in the province of Puntarenas, where south of the Cordillera of Talamance (Continental Divide) there occurs an isolated range, the Fila Cruces, of approximately 30 kms. in length, and with elevations of up to 1500 m. Between this range and the Cordillera of Talamanca is the valley of the Rio Coto Brus, a relatively low lying area with elevations less than 1000 m and with a strong dry season of four months with little cloud cover. There are no records of creon from this valley, which averages about 25 kms. in width. About 6 kms. south of the town of San Vito de Java is the Las Cruces Tropical Garden, situated at an elevation of about 1200 m on the northern flanks of the Fila Cruces. The property includes a forest preserve of over 100 hectares extending down to the Rio Java at almost 1100 m, and then up the other side of the valley of this river. Here, and presumably throughout the Fila Cruces in similar environments, occurs an isolated and distinctive subspecies of creon which we take pleasure in dedicating to its discoverer, Mr. Thomas Taylor.

## Pyrrhopyge creon taylori Nicolay & Small, new subspecies Figures 1A, 1D, 2

Male: Length of forewing, 28 mm  $\pm$  1; holotype 28 mm. Upperside: forewing a dark, shining bronze-purple with a relatively narrow, vaguely defined dark border on the outer margin and the apex. Hindwing with the disc shining purple with an even deeper bronze sheen, the dark border of the wing margin somewhat wider than that of the forewing and more sharply defined. There is a single orange-red sub-tornal spot in space 1-1b, the same size and form as in the nominate species. Underside: the purple coloring of the upper side is repeated but without the shining brilliance, is more subdued and has a smoky cast. The sub-tornal orange-red spot of the upper side is repeated in like manner. Fringes concolorous with the dark outer border.

The abdomen, thorax, tegulae, collar, leg clothing are black; the palpi and head are covered with intermixed dark reddish-brown and black hairs.

Female: Length of forewing,  $33 \text{ mm} \pm 1 \text{ mm}$ ; allotype 33 mm. Upper and undersides with all coloring and maculation the same as in the male.

Holotype male, Finca Las Cruces, San Vito (1150 m), Puntarenas, Costa Rica, 23 VI 1976, G. B. Small, Jr. Collector. Allotype female, same locality and collector, 24 VI 76. There are 54 male and 20 female paratypes collected by G. B. Small at the type locality with dates ranging from 22 VI to 3 VII 1976. Additionally, there are 9 male and 1 female paratypes

collected by Thomas Taylor from the type locality dated 13-20 VI and in VIII 1971. The holotype is deposited in the Allyn Museum of Entomology, Sarasota, Florida, the allotype in the U. S. National Museum collection, Washington, D. C. Paratypes are deposited in the British Museum (Natural History), The American Museum of Natural History and the Carnegie Museum of Natural History.

As in the case of the subspecies *lilliana*, the male genitalia clearly indicates the subspecific relationship of *taylori* to nominate *creon*. And, unlike *lilliana*, the facies and general configuration of *taylori* is much closer to *creon*, the primary and notable difference being only the basic color. The shining bronze-purple color is unlike that of any other species of the genus with which we are familiar. A striking feature of the *creon* complex of 3 subspecies is that there are no known intergrades, nor have we seen or taken any specimens that could not be placed at once in the correct subspecies. Yet, the male genitalia of all three show little or no difference and, in fact, are absolutely identical, even to the rather subtle asymmetry of the valvae.

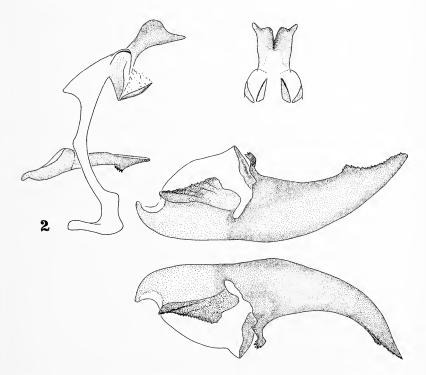


Fig. 2. Male genitalia - Pyrrhopyge creon taylori - lateral view of uncus, aedeagus in place, inner surface of both valvae and a ventral view of the uncus.

#### Discussion

It is apparent that notwithstanding its considerable capabilities for strong flight, *creon* is a very sedentary insect, for gaps of unsuitable territory of no more than 30 to 40 kms. are sufficient to keep populations separated.

All of the subspecies have the following traits in common:

- (1) individuals are numerous, even abundant, at suitable places and seasons.
- (2) males perch with outstretched wings on the tips of leaves from 8 to 40 feet above the ground.
- (3) the perching behavior of the males commences around 9:30 a.m., is most prevalent from this time until about 11 a.m. and ceases altogether about 12:30 p.m.
- (4) perching males are quite belligerent toward other passing lepidoptera, but are unwary and easy to capture.
- (5) females are much more rarely seen, and then usually searching for the larval foodplant.
- (6) both sexes are partial to a wide variety of flowers, particularly *Eupatroium* and are most frequently seen thereon between 8 and 9 a.m. (later at higher altitudes and/or depending on weather conditions.)

On the other hand, there appear to be certain differences in the behavior of the various subspecies.

P. creon lilliana perches somewhat lower than the other subspecies, usually from 8 to 16 feet above the ground. P. creon creon often perches extremely high and is therefore usually quite difficult to net except when at flowers. P. creon taylori appears to perch somewhat higher than lilliana but lower than creon. Since lilliana and taylori have been taken only at two localities and one locality respectively, the data on them are perhaps influenced by the nature of the terrain where they were taken, and may therefore be inconclusive.

At Santa Fe, Veraguas, males of creon creon were seen by both authors to fly vitually ceaselessly under the canopy of a mature wet forest at heights of 12 to 20 feet above the ground evidently looking for females. They settled very infrequently, and did not return to a given perch as in normal perching behavior, making it almost impossible to catch them. This behavior pattern is perhaps limited to the interior of forests. In any event, at this locale no individual was seen to engage in "normal" perching behavior, either in the interior of the forest or along its borders. Such behavior has never been observed in *lilliana* and seems to be only occasional in *taylori*.

In view of the considerably different appearance of *lilliana* from typical *creon*, and the differences in habits mentioned above, it may be that *lilliana* should be considered a full species. On the other hand, the genitalia of *creon* and *lilliana* are essentially identical, and *lilliana* is clearly derived

from creon stock. So, it appears that until some evidence of breeding incompatibility between them may be produced, the relationship between these allopatric taxa is best expressed by the subspecific concept.

Unfortunately, nothing is known at present about the foodplants or life histories of *creon* and its subspecies.

Specific records:

Recorded below are the data on material studied in the institutional collections as indicated: (BM) British Museum (Natural History); (AM) American Museum of Natural History; (USNM) U.S. National Collection, Smithsonian Institution; (AME) Allyn Museum of Entomology; localities without an institutional designation are those collected by the authors.

```
Pyrrhopyge creon creon: No data 6 ♂ 2 ♀ (BM), (USNM)
   Costa Rica: 6 ♂ 2 ♀ (BM)
     Tres Rios
                     2 of (BM)
     Cartago
                   3 ♂ 2 ♀ (BM)
           Moravia de Chirippo (1100m) - August
     Guanacaste
                       1 ♂ (BM)
     San Jose
                    1 of (AM) 1 of (USNM)
     San Geronimo
                         4 ♂ (USNM)
     Heredia
           Volcan Barba (2000 m) - August
     Puntarenas
           Monteverde (sight record - GBS)
  Panama':
     Chiriqui
                   4 \circlearrowleft 6 \circlearrowleft (BM); 1 \circlearrowleft 1 \circlearrowleft (USNM)
           Sta. Clara (1200 m) July 3 of (GBS)
           Cerro Colorado (Continental Divide) 1450 m July-Oct.
             40 ♂ 10 ♀ (GBS)
                    1 ♂ (BM)
     Veraguas
           Sta. Fe (800 m) Sept. 1 & (GBS) 2 & 1 & (SSN)
     Cocle'
           El Cope (600 m) Dec. 1 & (GBS)
   Colombia 1 ♂ (BM) (?)
Pyrrhopyge creon lilliana
  Panama':
     Panama'
           Cerro Campana (800 m) July-Dec. 50 ♂ 8 ♀ (GBS)
     Cole'
           La Mesa (800 m) Dec. 1 & (GBS)
Pyrrhopyge creon taylori
   Costa Rica:
     Puntarenas
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Finca Las Cruces, San Vito (1150 m) July-Aug.

50 ♂ 17 ♀ (GBS) 6 ♂ (AME)

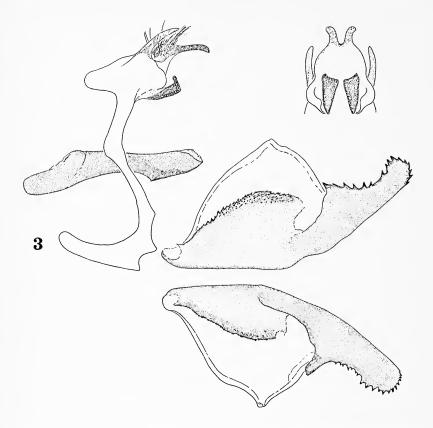


Fig. 3. Male genitalia - Pyrrhopyge sangaris - lateral view of uncus, aedeagus in place, inner surface of both valvae and a ventral view of the uncus.

The concept of this paper, begun more than three years ago, was originally limited to a discussion of the species *creon* and a description of the new subspecies *taylori*. Subsequent discovery of two male specimens of *Pyrrhopyge sangaris* Skinner, and more notably, two male specimens of *Mimoniades (Pyrrhopyge) aerata* Godman & Salvin in the Carnegie Museum collection provided us with the incentive and material to expand this study to include all three species listed by Evans (1951) at the beginning of his VIII. Hygieia Group.

#### Pyrrhopyge sangaris Skinner

Figures: 1H, 3

Pyrrhopyge sangaris Skinner, 1921, 32: 236-237. Bell, 1931, 39: 467. Evans, 1951, Part I, p 31.

Sangaris has never been illustrated. Superficially it is similar to creon, but all wing shapes are more sharply angular and there is no mistaking the

lustrous bronze-green color of sangaris as contrasted to the deep, shining blue of *creon*. Skinner's original description is quoted below. The male is figured together with an accurate line drawing of the genitalia.

" .--Palpi crimson with tips black. Abdomen and legs dark green-black.

Upperside. Primaries shining green-black. Secondaries shining green-black, somewhat darker than the primaries, with a blood-red spot near the anal angle. This spot is quadrate, 4 mm. wide and is 3.5 mm. from the inner margin and about the same distance from the outer margin.

Underside. Primaries as above but lighter in color with the crimson spot repeated but somewhat smaller and rounder. Expanse (one wing) 23 mm. Inner margin of hind wing 21 mm.

Type one male in the collection of The Academy of Natural Sciences of Philadelphia, taken at Hacienda Cincinnati, Sierra San Lorenzo, Magdalena, Colombia, July 23rd, 1920, Academy Colombia Expedition, Rehn and Hebard.

This handsome species has a superficial resemblance to *creon* Druce but has the shape of *phidias* Linn."

A total of 5 specimens of sangaris were examined in the course of this study. Three in the British Museum (Natural History), 2 males and a female from Onaca, Santa Maria, Colombia. Two males in the Carnegie Museum are from Valpariso (4500 ft.), Dept. of Magdalena, Colombia, December.

#### Mimoniades aerata (Godman & Salvin) new combination

Figures: 1G, 4

Pyrrhopyge aerata Godman & Salvin, 1879: 152, pl 14, fig 3. Mabille & Boullet, 1908: 177, 182. Draudt in Seitz, 1922, 5: 839, pl 166a. Bell, 1931, 39: 468. Evans, 1951, Part I, p 31.

As far as can be determined, the two male specimens of aerata in the Carnegie Museum of Natural History are the only two known: the type, a female in the British Museum (Natural History) is still unique in that collection. Upon examination of the male genitalia, it became readily apparent that aerata, belongs to the genus Mimoniades and not Pyrrhopyge. The antennal apiculus and wing venation are also characters compatible with these features found in Mimoniades. A description of the male follows:

Male: Length of forewing, 28 mm. Upperside: forewing shining bronzegreen with darker shading on the outer third of the wing. Hindwing bronzegreen with the basal half covered with back hairs of mixed lengths and density, and all veins somewhat darkened. Underside: bronze-green, the forewing unmarked, the hindwing with 5 orange-red spots, one each in interspaces 1 c and 2, then across the cell (the largest), interspace 6 and a small adjoining spot outside the cell. Cilia concolorous dark green. The

abdomen with a full-length narrow, dorsal black stripe, laterally with 6 orange-red striped alternating with narrow black stripes. The anal tuft, vental surface of the abdomen and leg clothing black. The thorax, palpi, head, collar and tegulae, black. There are two inconspicuous pale yellow tufts of hair in the collar located just behind the very minute and inconspicuous yellowish tufts of hair at the base of the antennae. The antennal club shaped as for the genus, rather stout and tapered to a blunt point only at or near the tip.

The male genitalia, figured here for the first time is of a similar form to that of the species *Mimoniades montra* Evans. The undivided uncus is long, without side flanges and in lateral view appears like a long, slender bird's neck and head. The valvae are asymmetrical and heavily spined, the aedeagus slender, bent ventrally and without spines.

All specimens known are from the Dept. of Magdalena, Colombia with specific data as follows:

Female type, Puebla Viejo, Sierra Nevada de Santa Marta (BM) Males (2) El Libano (6000 ft.) Dept. Magdalena, Colombia (May)

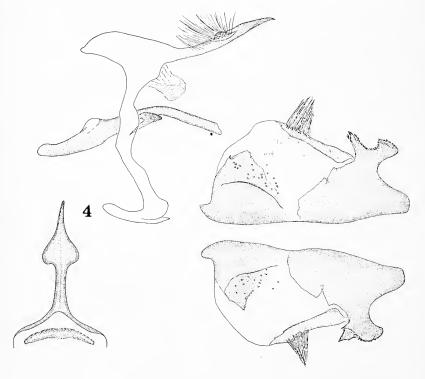


Fig. 4. Male genitalia - Mimoniades aerata - lateral view of uncus, aedeagus in place, inner surface of both valvae and a ventral view of the uncus.

Acknowledgments. We wish to express our appreciation to all who have helped in the preparation of this paper. To those individuals entrusted with the collections in their care—Harry Clench, the Carnegie Museum of Natural History, R. I. Vane-Wright, the British Museum (Natural History), Dr. F. H. Rindge, the American Museum of Natural History, Dr. Lee D. Miller, the Allyn Museum of Entomology and Wm. D. Field, the U. S. National Museum—go our thanks for allowing us access to study the material in these collections. And our grateful thanks to Robert Robbins for reading the manuscript with a critical eye and offering suggestions and constructive comments for its improvement.

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#### Errata: Scott 14:2; Scott 17:50; Scott & Scott 17(2)

Some unfortunate printer's errors were made in my recent papers. In vol. 14, p. 2 the sentence "In patrolling, species, interactions occurred predominantly when resting males investigated moving objects." is wrong and must be deleted. In vol. 17, p. 50 the upside down 1 and 3 after "Wet Mtn. Valley and Salida" should be deleted and a 1 placed in column D, a 3 in column E. The remaining corrections are for vol. 17, no. 2. On p. 73 our address is Estes not Eses St. P. 75, paragraph 2, a comma after timberline, not after hermodur. Paragraph 3, a period after "here". Paragraph 4, delete period after polyxenes. P. 76, line 8, "is", not "in". P. 76, paragraph 3, Rutaceae is correct spelling. P. 77 add Prunus to P. eurymedon hosts. P. 80 Melilotus is correct spelling on line 13. P. 81, paragraph 7, line 3, should read "plants. Several broods; there are...". Delete last two lines on p. 81. P. 82, line 7 and p. 83, line 8, poplar, not popular. P. 82, paragraph 2, lines 4 and 5 should read "and late Aug.). Common; the second broad is less common than the first but is sometimes common in Denver,...". Same paragraph, line 7, parvifolia is correct spelling. P. 84, paragraph 4, insert "all" after "12 loc.:". P. 85, last paragraph, a comma instead of a parenthesis after "Sept. 13", and "period" not "perio." in last line. P. 87, line 1, should read "two or three broods in...". P. 88, paragraph 2, 21 not 2 localities, in first line. P. 91, first two paragraphs should be moved to bottom of page, and the end of the C. oetus paragraph should read "flowers of all colors, frequently composites, apparently preferring blue over yellow ones.", and C. meadii should start a paragraph. The last three paragraphs on p. 92, and the first two paragraphs on p. 93, should be deleted. P. 95, paragraph 2 and p. 99, paragraph 3 should read "dos P." not "Dosp." or "dosp.". The last paragraph on p. 99 and the first nine lines on p. 100 should be deleted. P. 102, line 4, should read "early June, late June-late July, Aug. 16-Sept. 13". P. 106, paragraph 3, line 3, insert "present on" before "the San Luis Valley...". P. 107, paragraph 5, line 6, should read "Larvae may feed on Bouteloua". P. 118, paragraph 5, line 7, should read "(6 only northeastward, 3 only southeastward)". Paragraph 6, line 7, add "P. acmon" after shasta. P. 119, paragraph 4, change E. dorothea to C. pertepida. Last paragraph, line 3, rhesus not urhesus. P. 120, paragraph 3, Phyciodes is correct spelling, and insert "& Convolvulus" after Aster. P. 127, paragraph 1, insert "possibly" after milberti. On back cover, the satellite photo refers to J. Scott and G. Scott, not Emmel & Shields. Note: if your copy of vol. 17, no. 2 lacks pp. 99-114, write to Scott Miller of the Santa Barbara Museum for a correct copy (address on inside front cover).

J. & G. Scott, 60 Estes Street, Lakewood, Colorado 80226

#### **Book Review**

A catalogue/checklist of the butterflies of America north of Mexico.

Lee D. Miller and F. Martin Brown, Lepidopterists' Society Memoir No. 2, 1981. 280 pp. (Lep. Soc. members \$5.00 cloth, \$10.00 hardbound; non-members \$8.50/17.00).

The long awaited Miller and Brown catalogue is now at hand. This volume was well worth the wait as it is a far more useful work than dos Passos' (Lepid. Soc. Memoir, no. 1, 1964) synonymic list. The authors are to be highly commended in giving the systematicist his most useful single book on the nomenclature of North American butterflies.

Full synonymies are given for each taxon from the generic level down. For each genus (and synonymic genera) the literature citation of its original proposal and the type species are presented. Under each species, besides a listing of all named subspecies (and synonomies), forms and aberrations, we are treated to the genus under which it was originally described, the citation of the original description, the type locality and the location and kind of type specimen when known. This alleviates us of the boring and time consuming task of pouring through the Zoological Record to find where something was described. Finally, and probably of most importance, there are over 650 footnotes which justify, explain or expand upon the main body of the text.

Overall, Miller and Brown are splitters, especially at the generic level. For example, they use 21 genera for Pieridae (13 in dos Passos), seven for Papilionidae (5), seven for Lycaeninae (1) and 16 for Polyommatinae (11). This is largely a result of raising dos Passos' subgenera to the generic level (e.g., Falcapica, Zerene, Aphrissa, Pyrisitia, Abaeis). Others are new genera proposed in recent reviews (e.g., Hyllolycaenaa, Hermelycaena, Euphilotes, Philotiella). Still others result from finally recognizing that some of our taxa are congeneric with, especially, Palearctic ones (e.g., Pontia, Artogeia, Aglais). On the other hand, there is a realization that some Nearctic genera are sufficiently distinct to warrant recognition (e.g., Basilarchia).

In any work of this sort, there are bound to be decisions not agreed upon by everyone, typographical errors not edited out and omissions. This book is no exception. My following comments point out some of these and are largely directed towards taxa that occur in Nevada and adjacent areas.

In a number of places (e.g., p. 60, 66, 116, 117, 121, 142) we are referred to a footnote as "see Note 000". These are perhaps the most annoying typographical errors as I wonder if I am missing some important bit of information. Footnote 557 (p. 177) is really note 571. The genera are sequentially numbered yet *Nathalis* and *Feniseca* are CXVII and *Enantia* and *Thersalea* are CXVIII; genus CXXXII (*Satyrium*) is followed by CXXXV (*Ocaria*).

A couple of other remarks are pertinent before turning to individual species. The first concerns taxa described from some of Lorquin's specimens. Difficulties with Lorquin's Utah and "Lac Sal" localities have been known for some time (Brown, J. Lepid. Soc. 21: 271-274, 1967). Miller and Brown restricted the type localities of Neophasia menapia, Apodemia mormo and Speyeria mormonia to the general area near or to the west of Pyramid Lake, Washoe Co., Nevada. I have no particular quarrel with the first two. The menapia could have come from nearly anywhere on the east slope of the Sierras. Likewise, mormo occurs in scattered pockets on the

valley floor and in lower canyons in the same general area. The mormonia presents a special problem. East slope Sierran populations in the Reno-Carson City area seem to fall into the concept of arge especially in their variable silvering. If this is where Lorquin took the types then there is a nomenclatural problem. We know that Lorquin was in the Carson City area from Behr's description of leto, but there are other lakes that could have been "Lac Sal" including Mono Lake and the Alkali Lakes east of the Warner Mountains.

Then there are a number of taxa that were proposed by Bauer (in Howe, The Butterflies of North America, Doubleday, Garden City, 1975). These are right on the fuzzy edges of validity under the "Code". All are treated adequately except Thessalia leanira oregonensis which is not mentioned. Miller and Brown's comments that apply to the other Bauer taxa (in Howe) apply to this taxon also.

Now to a number of comments on various species.

Erynnis persius - the four "subspecies" are listed although Burns (Univ. Calif. Publ. Ent. 37, 1964) suggested against recognizing any names in this complex until they were better known biologically.

Pyrgus communis/albescens - these are presented as separate species "on the advice of H. A. Freeman" but we are given no hint of why.

Anthocharis cethura/pima - retained as separate species although it is recognized by collectors in the southwest that there are intermediate populations.

Atlides halesus - the western populations are still jumping around from name to name: estesi Clench, corcorani Gunder, corcorani Clench, corcorani dos Passos.

Callophrys comstocki/lemberti - these are retained as separate species although there are several intermediate populations. These should, at least, be as subspecies (comstocki has priority). I prefer treating them as taxa under sheridanii.

Incisalia fotis - schryveri, fotis, mossii, bayensis, doudoroffi and windi are treated as subspecies. The Sedum feeding taxa are undoubtedly separate from nominate fotis.
 Euristrymon - Clench (J. Lepid. Soc. 32: 277-281, 1978) synonymized this with Fixsenia Tutt. The latter is not even mentioned.

Parrhasius m-album - why this genus, did I miss something after Panthiades?

Euphilotes - Mattoni's (J. Res. Lepid., 16: 223-242, 1977) generic revision is followed yet there is some inconsistency within the species. Mattoni recognized battoides, enoptes, mojave, rita and spaldingi as good species. Shields (Bull., Allyn Mus. 28, 1975; J. Res. Lepid. 16: 1-67, 1977) recognized battoides, enoptes (with mojave as a subspecies and rita (with spaldingi as a subspecies). Here Miller and Brown follow Shields except that rita is split into two species, rita and pallescens.

Lycaeides melissa - fridayi is recognized and paradoxa takes precedence over inyoensis.

Icaricia acmon texana - a slight error here as this was originally described as a Plebejus.

Agriades franklinii - a totally new face for the species we have known so long as aquilo or glandon. The latter are apparently Palearctic.

Speyeria coronis gunderi - it has been known for some time that gunderi refers to a zerene population. Unfortunately it was described from an area where red Sierran and blond Great Basin zerene mix. However, the holotype is quite indistinguishable from populations going under the name of cynna. Thus gunderi should be moved to zerene with cynna as a synonym.

Phyciodes pratensis - takes precedence over campestris under the "First Reviser" tenet.

Euphydryas anicia - I'll bet that ab. "duncani" (TL Sta. Catalina Mtns., Arizona) refers to hermosa rather than wheeleri.

Basilarchia lorquini - in a footnote it is stated that "fridayi" is a hybrid of this species and B. weidemeyerii nevadae. The weidemeyerii taxon involved is latifascia. Before latifascia was described much of western Great Basin weidemeyerii were considered nevadae, a concept is now restricted to populations in the Spring and Sheep ranges in southern Nevada. Thus, the older literature (correctly at the time) reported nevadae as one of the parent taxa.

Asterocampa - I'm still amazed that we maintain so many monotypic species.

Coenonympha - retention kodiak, inornata, ochracea, ampelos and california as separate species under the concept of a tullia superspecies. This appears to be a reasonable means of handling this difficult group.

Coenonympha ochracea brenda - recent studies indicate that brenda does not apply to Great Basin populations or, for that matter, to ochracea. This is being worked out by R. E. Gray.

Cercyonis pegala - some changes were made in the synonymy of western members which were badly needed, especially recognition of certain western Great Basin populations under the name stephensi.

Cercyonis oetus - the taxon pallescens Emmel and Emmel (Pan-Pacific Entomol. 47: 155-157, 1971) was omitted.

These are, for the most part, minor points that can be cleared up at a later date in an "Addenda et Corrigenda" once there is sufficient input from others. Again, the volume is an extremely valuable contribution to systematic Lepidopterology and should be on all our shelves.

George T. Austin, Nevada State Museum, Capitol Complex, Carson City, NV 89710.

The catalogue is an absolutely necessary work for anyone with the slightest systematic concerns with the Holarctic butterfly fauna. Although there will be many arguments based on the arrangement of taxa, the meat is here.

Since I feel only competent to comment on my own group, the Scolitantidini, I have tried to extrapolate errors of fact and typography to those of the whole book. Thus there are two such errors in four pages: 1) citation of bohartorum as a synonym of Philotiella speciosa (it is clearly a valid subspecies and perhaps a species with no published report to the contrary), and 2) a 000 note on p. 121. At this rate 100 errors can be expected in the some 200 pages.

For the Polyommatinae it is unfortunate the authors did not follow Eliot's classification [1973, Bull. Brit. Mus. N. H. 28(6)]. Recognizing Eliot's sections as tribes would place *Brephidium*, *Leptotes*, and *Zizula* each in its own tribe. Their placement here in **Lampidini** is misleading. Most serious, *Hemiargus* is also placed in **Lampidini**, where it is clearly in **Polyommatini**, surely one of the best demarked groups of Blues.

Interpretatively, I would like to point out that *Euphilotes spaldingi* (511 c) is clearly specific on morphological, developmental, and behavioral grounds. *E. rita* and *E. pallescens* may also be treated as one species based upon presumptive

intermediates found in Washington Co., Utah (Shields, pers. comm.). There are data, both biological and morphological, to indicate *E. mojave* and *E. enoptes* can be considered distinct. These points, however, have not been formally published, and I can in no way fault the authors concerning their use.

No doubt every specialist will offer his quarrels. Miller and Brown should be pleased thereby that such arguments in reality serve to point out the lack of meaningful systematic revisions for many groups. The authors, in their introduction, take pains to point out the classification used represents their joint opinion, and that they were not in agreement on some matters. Such recognition makes the message that no taxonomy is cast in stone.

We now can look forward to the day there is a similar catalogue of the Palearctic butterfly fauna.

R. H. T. Mattoni, 9620 Heather Road, Beverly Hills, CA 90210.

### THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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Manuscript Format: Two copies must be submitted (xeroxed or carbon papered), double-spaced, typed, on 8½ x 11 inch paper with wide margins. Number all pages consecutively and put author's name at top right corner of each page. If your typewriter does not have italic type, underline all words where italics are intended. Footnotes, although discouraged, must be typed on a separate sheet. Do not hyphenate words at the right margin. All measurements must be metric, with the exception of altitudes and distances which should include metric equivalents in parenthesis. Time must be cited on a 24-hour basis, standard time. Abbreviations must follow common usage. Dates should be cited as example: 4. IV. 1979 (day-arabic numberal; month-Roman numeral; year-arabic numeral). Numerals must be used before measurements (5mm) or otherwise up to number ten e.g. (nine butterflies, 12 moths).

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Name Citations and Systematic Works: The first mention of any organism should include the full scientific name with author (not abbreviated) and year of description. New descriptions should conform to the format: male: female, type data, diagnosis, distribution, discussion. There must be conformity to the current International Code of Zoological Nomenclature. We strongly urge deposition of types in major museums, all type depositions must be cited.

**References:** All citations in the text must be alphabetically listed under Literature Cited in the format given in recent issues. Abbrevations must conform to the *World List of Scientific Periodicals*. Do not underline periodicals. If four or less references are cited, please cite in body of text not in Literature Cited.

Tables: Tables should be minimized. Where used, they should be formulated to a size which will reduce to 4 x 6½ inches. Each table should be prepared as a line drawing or typed with heading and explanation on top and footnotes below. Number with Arabic numerals. Both horizontal and vertical rules may be indicated. Complex tables may be reproduced from typescript.

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### THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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## THE JOURNAL OF RESEARCH ON THE LEPIDOPTERA

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William Hovanitz

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Manuscripts may be sent to the Editor at:

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#### Editorial

The recent appearance of the Miller and Brown A Catalog/Checklist of the Butterflies of America North of Mexico, published by the Lepidopterists' Society, was a well anticipated event, an event which hopefully would have established a stable nomenclatorial framework for North American butterfly taxonomy for a long time to come. There has been an immediate reaction to this work from several quarters. The critique published below, by Ehrlich and Murphy, has already been widely circulated and formally supported by a significant number of recognized authorities. For reasons which are unclear, the editors of The Journal of the Lepidopterists' Society refused publication of the critique, although it was properly first submitted there. We strongly assert that forward movement in any scientific endeavor cannot be achieved without intelligent consideration and discussion. It should, consequently, be made quite clear that this journal, as a scientific publication, can take no position in the matter except to strongly express the desire to have the issue thoroughly aired. We have invited Miller and Brown to rebut the criticism, and they have agreed to do so presently. The basic issue is substantive to all Lepidopterists, not only in this region, but internationally. We cordially extend an invitation for all relevant considered opinion on the matter.

We take this opportunity to emphasize our support of and good relationship with the Lepidopterists' Society. That organization has had a great historical impact on all workers in the field in North America, and continues as the organization binding all Lepidopterists in the region together. We in no way wish to convey any sense of competition between publications of the Society and this journal. We are all working toward the same objective, have an enormous body of information and opinion to disseminate, and will continue to do so in a cooperative fashion.

RHTM

#### **Butterfly Nomenclature: A Critique**

Paul R. Ehrlich

and

Dennis D. Murphy

Department of Biological Sciences, Stanford University, Stanford, California 94305

#### Introduction

There are two main goals of formal, latinized nomenclature. The first is permitting unambiguous communication about what organisms are being

discussed. The second is expressing, to whatever degree possible, the evolutionary (phenetic or cladistic) relationships among those organisms. These goals are not antithetical, but we contend here that the first has been almost totally ignored lately by many butterfly taxonomists. In part this is because of a confusion of the nomenclature of butterflies (the system of names applied to them) with the taxonomy of butterflies (their classification into groups). And in part it is due to a nearly automatic trend for specialists to inflate the taxonomic rank of the group on which they work.

The basic element of the scientific system of nomenclature is the latinized binomen. The binomen is made up of two parts, the generic name followed by the specific name. The binomen is supposed to be a standard, stable label, understandable to workers in all locations—unlike "common" names that vary from place to place. Thus while the Americans call a certain butterfly the "Mourning Cloak" the English call it the "Camberwell Beauty", the Germans, "Trauermantel"; Swiss, "Sorgmantel"; French, "Le Morio"; and Spanish, "Antiopa"; scientists everywhere should call it Nymphalis antiopa.

The preamble to the International code of Zoological Nomenclature states: "The object of the Code is to promote stability and universality in the scientific names of animals." It is instructive, however, to examine how well the formal nomenclature of butterflies has achieved stability of names.

#### **Trends in Generic Nomenclature**

We have examined the latinized names in seven standard works on Nearctic butterflies: Holland (1898, 1931); McDunnough (1938); Ehrlich and Ehrlich (1961); dos Passos (1964); Howe (1975); and Miller and Brown (1981). In what follows we will often refer to these works by the dates only. We traced the history of only those 1898 names in the Papilionoidea that were still considered to represent valid species in 1961, and were not of questionable residence ("strays" picked up occasionally along the southern border of the U.S.). For example, the 1898 names Lycaena icarioides, Neonympha phocion, and Melitaea arachne (in 1961 Plebejus icarioides, Euptychia areolata, and Poladryas pola respectively) were included, while Lycaena ardea (in 1961 considered a subspecies of P. icarioides), Chlosyne chinatiensis (not described until 1944), and Dircenna klugii (doubtful resident) were not.

Changes in the generic names of the 262 species that fit these criteria in 1898 were followed through the subsequent six publications. The average species changed generic name 1.8 times, that is, it has had almost three different generic names in seven standard works. There have, of course, also been a large number of changes in the specific name or switches between specific and subspecific status. Thus three different names in 84

years—a new name every 28 years—is a very conservative estimate of the amount of name changing. Nomenclatural instability, rather than stability, has been the rule.

Consider some examples. Although in the United States the common name Mourning Cloak has remained stable for the entire eighty-four years, Holland first called it *Vanessa antiopa* and then *Aglais antiopa*, whereas everyone from McDunnough onward has called it *Nymphalis antiopa*. Conversely, while everyone from Holland through Howe called the Spicebush Swallowtail *Papilio troilus*, Miller and Brown suddenly declare it to be *Pterourus troilus*. But these have been relatively stable names. Satyrodes canthus (1898) became S. eurydice (1931, 1938), then Lethe eurydice (1961, 1964, 1975), and finally Satyrodes eurydice (1981).

Some species have weathered nearly as many generic names as publication appearances. Thecla m-album (1898, 1931) has been in Strymon (1938), Panthiades (1961, 1975), Eupsyche (1964), and Parrhasius (1981). Others have simply bounced back and forth between genera. Thecla augustus (1902, 1931) moved to Incisalia (1938), to Callophrys (1961) back to Incisalia (1964), back to Callophrys (1975), and finally back to Incisalia (1981).

As the example of "Incisalia-Callophrys" augustus indicates, continuing disagreement on whether or not to split a genus may inflate the number of generic name shifts. But such cases are only a minor part of a general trend of fractioning genera. Within the sample set of species there has been a 100 percent increase in the number of genera, and therefore a halving of the number of species per genus, during the past 50 years.

This generic splitting occurred in two waves. The 262 species were in 46 genera in 1898, 49 in 1931, 69 in 1938, 71 in 1961, 67 in 1964, 72 in 1975 and 100 in 1981. Thus from 1938 to 1975 the number of genera remained more or less stable. The McDunnough list increased the number of genera some 40 percent over Holland; Miller and Brown ended that period of relative stability with a similar increase. Our contention is that the McDunnough changes were largely justifiable and those by Miller and Brown largely unjustifiable.

In general the name changes made between 1931 and 1938 reflect the fractioning of a few very large, sometimes polyphyletic genera like Chlorippe, Melitaea, Satyrus, Thecla, and Lycaena, and the recognition of clear cases of priority that did not involve splitting (e.g. Anaea for Pyrrhanaea, Polygonia for Grapta). The large increase in the number of genera between 1931 and 1938 is almost entirely accounted tor by the splitting of two genera, the blues (then Lycaena) and hairstreaks (Thecla). The changes between 1975 and 1981, in contrast, reflect in large part, a refusal to recognize subgenera in disregard of both basic goals of nomenclature outlined in the introduction.

Some name changes are almost entirely due to changing "styles" in

splitting and lumping. Consider the case of Euphydryas editha. No one doubts that Melitaea cinxia is more closely related evolutionarily to Euphydryas phaeton than to Boloria pales (all are the type species of their genera). But Melitaea in the broad sense (including phaeton) was considered too large to be a single genus and Euphydryas was generally recognized as having generic status by the late 1930s. Thus Melitaea editha became Euphydryas editha. The latter name remained stable until Higgins (1978), recognizing several evolutionary groups within Euphydryas, split up that genus into four genera, concluding that the name of Euphydryas editha should be changed to Occidryas editha.

Note that splitting Euphydryas from Melitaea does not make the slightest difference in the amount of relationship communicated by the specific name. For example the first split focussed attention on the relatively close relationship between Euphydryas phaeton and Euphydryas editha but obscured the somewhat more distant, but no less important, relationship between Euphydryas editha and Melitaea (= Chlosyne = Charidryas) palla. Whether or not the old Melitaea should have been split is a matter of taste, especially since relationships within the Melitaeini (sensu Ehrlich and Ehrlich, 1961) are still not well understood. But we tend to think it was useful from the point of view of the communication goal of nomenclature. The advantage to lepidopterists who must frequently discuss species groups within the old Melitaea is probably greater than the inconvenience for non-specialists for whom the large, easily recognized Melitaea was more useful. As we will discuss below, however, there is no conceivable justification for splitting Euphydryas.

The change of Graphium marcellus from the genus Papilio to the genus Graphium was justifiable because the old genus Papilio was polyphyletic. Graphium marcellus is much more closely related to Lamproptera curius than to Papilio machaon (or Battus philenor). Only by placing all of the Graphiini and Papilionini (sensu Munroe and Ehrlich, 1960) into a single genus could marcellus be made congeneric with machaon without recreating a polyphyletic entity.

#### The Rule of Obligatory Categories

In the case of *Graphium marcellus* the need to change the generic name was clear—it could not reasonably remain in the genus *Papilio* (whether it should be in the genus *Eurytides*, a subset of the genus *Graphium* as used here, is a more difficult question). But how does one evaluate the case of the proposed splitting of *Euphydryas*? Here one must somehow balance the needs of different "user" groups.

There is, fortunately, a taxonomic guideline that is very useful in determining where to draw the line. The key point to remember is that taxonomists should not be creating nomenclature primarily for their own use, but as a general tool useful to all biologists. The rule is: obligatory

categories above the species level should be kept conservative. What are "obligatory categories"? Categories are ranks in a hierarchic classification. Obligatory categories (e.g., Mayr, 1969, p. 89) are those that every animal must be placed in when it is described: species, genus, family, order, class, and phylum. It is especially important to follow the rule with respect to genera. As Ernst Mayr wrote (1969, p. 239): "Splitting is particularly deleterious on the generic level. The generic name is part of the scientific name of an organism and can therefore be employed more advantageously to indicate affinity than can the name of any of the other higher categories."

If this rule is followed then there can be the best of both worlds. Communication with non-specialists is facilitated, because it is normally the obligatory categories that are used for this purpose. But there remains a wealth of non-obligatory categories with which a taxonomist can communicate finer points of difference—superfamilies, subfamilies, tribes, subtribes, subgenera and species groups, to name the ones most used by Lepidopterists.

#### Effects of ignoring the Rule

As we have seen, it is primarily generic splitting that has destroyed the stability of the latinized names of butterflies. For example Higgins' (1978) splitting of Euphydryas is an attempt to raise what would be reasonable species groups (or weak subgenera) to generic status. He provided no discussion of the basis on which he decided that the relationship between E. editha and E. chalcedona was more important to communicate in the binomen than that between E. chalcedona and E. phaeton. Higgins also promoted the weak genus Euphydryas to full tribal level, without consideration of what that categoric inflation meant for the taxonomy of the checkerspots (and nymphalids) in general. Presumably the old tribe Melitaeini (and other tribes of the Nymphalidae such as the Argynnini) would have to be raised to subfamily level—implying that the checkerspots are a group as distinct from, say, the fritillaries as the Papilioninae are from the Parnassiinae. It would further require that the Nymphalidae (sensu 1961) be divided into eight or so poorly defined families.

Miller and Brown (1981) appear to have seen the absurdity of tribal status for Euphydryas, but nonetheless recognized Higgins' daughter genera Occidryas, Eurodryas, and Hypodryas. This, however, leads to something equally absurd within the Melitaeini: considering the differences between Phyciodes and Occidryas to be of the same order as those between Occidryas and Hypodryas. In fact Euphydryas is an extremely cohesive group, not just morphologically but in its behavior, reproductive biology, chemistry of host plant choice, and allozyme genetics.

Perhaps even more important, *Euphydryas* are now widely used in the research of population biologists. It would be as ill-advised to change the

scope of that generic name today as it would have been to accept the proposal (made some years ago) that the generic name of *Drosophila melanogaster* be changed. It is precisely that sort of nonsense that frequently leads evolutionists, ecologists and others to ignore the important contributions of taxonomists and damages the reputation of taxonomy as a discipline.

Again, Euphydryas is hardly an isolated instance. Pieris rapae, a name stable for more than a century and enshrined in thousands of papers in the economic literature is now supposed to be changed to Artogeia rapae. It is true that the type of Pieris, P. brassicae, is morphologically and chromosomally a rather unusual species, but the difference between the two could have remained expressed, as it has for decades, by subgenera. It is doubtful that most scientists will accept this change anyway, any more than they will use Occidryas editha. The problem then becomes the acceptance of the change by some scientists and the confusion that ensues.

Other examples abound in Miller and Brown (1981). Zerene was considered a subgenus of Colias in the careful revision of the Pieridae by Klots (1933) and in his treatment of Colias in Ehrlich and Ehrlich (1961). Should not the grounds on which that judgment was reversed be published? Similarly what is the biological justification for splitting up Eurema. It seems a most uniform assemblage, and again Klots found no reason for fragmenting it into several genera. Taxonomies should not be modified by fiat, but only with the publication of thorough analyses backed by data.

Among the least warranted changes in the Miller and Brown list is the resurrection of a series of antique generic names, mostly proposed by Huebner (1819), within Papilio (sensu 1975). Are we to assume that the judgment of Jacob Huebner, based on the very limited material and information of 150 years ago, should take precedence over that of Eugene Munroe, a modern taxonomist with access to virtually all papilionid species? Huebner was a giant among his contemporaries, but in his time the concept of a genus was far from its modern state. In Munroe's classic paper on the Papilionidae (1961) he states: "...I have failed to find simple and reliable differentiating characters for what appear to be the natural groups of Papilionini. I therefore include all the species in a single genus." And yet everyone is now expected to drop names used since childhood and, for example, call the tiger swallowtail Pterourus glaucus.

Huebner's approach to differentiation at the generic level is particularly evident where he (1819) proposed the generic name Heraclides for Papilio thoas. The three species available to Huebner for consideration and placed by Miller and Brown in Heraclides (thoas, cresphontes, and androgeus) were actually divided by Huebner into two genera. The superficially almost indistinguishable thoas and cresphontes were placed in Heraclides and androgeus was split off in Calaides. Furthermore, in the

same publication the generic names Jasoniades and Euphoeades were proposed for Papilio turnus and P. glaucus respectively—two color morphs of the same swallowtail! Both names were buried by the priority of Pterourus, which had appeared 40 years previously and been rightfully ignored.

It seems unnecessary to discuss in detail the pointless fragmentation of genera like Anthocaris, Lycaena (sensu 1938), Boloria, Chlosyne, Nymphalis, and Precis, and more complex cases where certain splitting may well have been justified (e.g., Philotes, Plebejus, some Theclini, Euptychia). One justification for the recent generic splitting has been that Europeans have done it (see Miller and Brown, 1979, also pp. ix and xvii of Ferris and Brown, 1981 and the nearly identical nomenclature in Miller and Brown, 1981). It is true that there has been a trend in Europe toward having a single species in each genus (which at completion will completely destroy the utility of binomial nomenclature). There was once a trend for European amateurs to name every individual, too (the "aberration" craze). But there is not the slightest reason for American lepidopterists to follow in their footsteps.

Another apparent justification for the recent ultra-splitting seems to have been the mistaken notion (Miller, 1981, p. 54) that the nomenclatural principle of priority is more rigid than it actually is (see Mayr et al, 1971) and that "the primary law of taxonomy involves the concept of binominal nomenclature" (Miller, 1981, p. 53). The primary laws of taxonomy have to do with how one arranges organisms into groups, not how one chooses to assign names (or numbers, or symbols) to those groups in order to communicate about the groups and their arrangement. An unfortunate emphasis on names rather than organisms seemingly has led to attempts to recognize the maximum number of genera—a sort of bizarre "conservation of generic names." The resultant trend toward all genera being monotypic, with the concomitant ignoring of subgenera, makes nomenclatural expression of relationships below the tribal level increasingly difficult.

In summary, the Miller-Brown catalogue is a superb historical review and bibliographic tool, and all who study butterflies owe them a great debt for their enormous effort. But their choice of names is simply unacceptable. Their names will not be used by most scientists working with butterflies, including taxonomists, and it will simply make communication even more difficult if some butterfly taxonomists persist in using them on the assumption that to do so is somehow "scientific" or "modern," or that the names are in some way "official." Remember there is no rule that, just because someone has proposed a new genus or resurrected an old one, the judgment must be accepted.

#### Recommendations

Unfortunately the Miller and Brown (1981) names have already been

used in two otherwise excellent books directed to laypersons (Pyle, 1981; Ferris and Brown, 1981), and our personal contacts and correspondence indicate widespread distress with the numerous name changes. To avoid further confusion we would like to make some recommendations for stabilizing the nomenclature of North American butterflies:

- 1). The generic nomenclature in Howe should be adopted, and no changes accepted in it except where required because of clear polyphyly or highly distorted "balance" (Mayr, 1969, p. 241). We recommend this not because we think that the nomenclature in Howe is perfect. It is, however, the widely available major compendium on Nearctic butterflies. It furthermore has a reasonable nomenclature that does not constitute a major departure from other post-1950 works. We are not sure that the splitting of Speyeria from Argynnis or Euphydryas from Melitaea was originally justified, but we are certain that to change such widely accepted names now would be foolish. It might be wiser to recognize Eurytides as a full genus as Munroe and Ehrlich (1960) did, but Graphium can be monophyletic and is widely used. Let it be!
- 2). Editors should routinely reject any work that suggests generic name changes from those in Howe if it does not contain a thorough biological justification for the change—polyphyly or imbalance. Papers should also be rejected unless all changes in rank are accompanied by a discussion of their consequences for the balance of the system as a whole. "Inclusion of all...species within a single genus...fails to recognize their wide generic and specific differences" (Higgins, 1978) and "something is going on with the coppers" (Miller and Brown, 1979) do not meet these criteria. Munroe's 1949 discussion "Some remarks on the genus concept in Rhopalocera" can still provide excellent guidance in this area.

The problem of generic splitting is now so serious that we believe the butterflies are about to go the way of the birds, where it is the common names that are used by virtually everyone for communication and the binomens, in addition to being unstable, give few cues to relationships. Do we all really want to use names (Pyle, 1981) like "immaculate green hairstreak," "Cuban crescentspot," and "western black swallowtail" instead of the shorter Callophrys affinus, Eresia frisia, and Papilio bairdii? Or names like "goatweed butterfly," "question mark," "waiter," and "crimson-banded black," that give no clues to affinity? In an attempt to arrest this trend we are going to petition the Lepidopterists' Society officially to adopt a list of approved generic names based on Howe (1975) to be used in its publications, and to appoint a diverse board to oversee its (hopefully rare!) revision.

Regarding species-level taxonomy, matters are more complicated. We won't go into the evolutionary problems here, except to say that they are much more complex than usually indicated in popular works on butterflies. Those interested in more details can get access to the literature through

Ehrlich (1961), Mayr (1963), Ehrlich and Raven (1969), and Grant (1981). Suffice it to say that splitting at the species level can be justifiable because lumping can conceal important biological differences (e.g., *Lycaena phlaeas* may really be very genetically different from *L. hypophlaeas*). Here again, though, we would tend to be conservative for purposes of communication and not deviate from the treatment in Howe without substantal evidence to justify the change.

We also feel strongly that revisions at the species level of Nearctic butterflies should be accompanied by exhaustive numerical taxonomic analysis and/or careful work on the biology of the organisms. The recent description of *Boloria acrocnema* (Gall and Sperling, 1980) could serve as a model for the sort of detailed analysis that should support any proposed new specific names in the Nearctic fauna. Whether or not one accepts their judgment, the *basis* for that judgment is clearly and unambiguously laid out. Our fauna is now so well known that little is to be gained by reshuffling names, or creating new ones, on the basis of genitalic dissections alone. Contrary to mythology, the shape of the genitalia is no magic indicator of taxonomic status (Shapiro, 1978).

On the other hand, little damage is done by splitting in the description of new subspecies. Since the classic work of Wilson and Brown (1953) it has been clear that most subspecies are not biological entities, and they relatively rarely figure in the evolutionary literature. But subspecies names do call attention to certain patterns of phenetic variation, do communicate information about those patterns among specialists, are useful politically in attempting to prevent the extinction of genetically distinct populations, and give pleasure to butterfly collectors. In short they can be conveniently used by specialists and equally conveniently ignored by others.

At the family-subfamily level we contend that the basic treatment in Ehrlich (1958) and Ehrlich and Ehrlich (1967) should be retained. It is the only recent work that considers the entire breadth of the butterflies and the balance of the groups within them in a context of other Lepidoptera and the insects as a whole. The butterflies are an evolutionary uniform group as insects go, and there is no reason for them to be divided into more than 5-6 families. People who revise one group invariably become impressed with the diversity within that group and want to raise the rank of the taxon they are revising. This urge leads to serious imbalances. For example, if the Satyrinae are considered to be a family with Euptychia and Lethe in separate subfamilies an imbalance is created. That is because there is much more difference between Papilio and Graphium (only in different tribes) than between Euptychia and Lethe.

This is not to say that the Ehrlich treatment necessarily should be permanent. Perhaps, for example, the Riodininae should be considered a family or the Libytheidae dropped to subfamily status. But suggested

changes at that level must be accompanied by a consideration of the relationships of all the major groups of the butterflies worldwide and the balance of insect taxonomy as a whole. Any changes should be based on more evidence or better techniques than the Ehrlichs used. Interestingly, a recent cladistic reanalysis of Ehrlichs' data (Kristensen, 1976) found no reason to alter the higher classification beyond dropping the libytheids to subfamily status.

Finally, we would like to reiterate a plea that has been made before (Remington, 1948; Munroe, 1960). It is that research on butterflies be focused much more strongly on studying the biology of these fascinating creatures and much less on continual shuffling of names. Butterflies are increasingly the subject of important research in ecology, evolution, animal behavior, and conservation biology. These are areas in which both professional biologists and amateur lepidopterists have made and can continue to make substantial contributions. Let's keep our nomenclature stable so that we can continue conveniently to talk about it among ourselves and tell the world about it unambiguously.

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## Early Stages of Speyeria nokomis (Nymphalidae)

James A. Scott and Sterling O. Mattoon

60 Estes Street, Lakewood, Colorado 80226 and 2109 Holly Avenue, Chico, California 95926

Abstract. The egg, larval stages, pupa, and developmental period of S. nokomis from the United States and Mexico are described and illustrated.

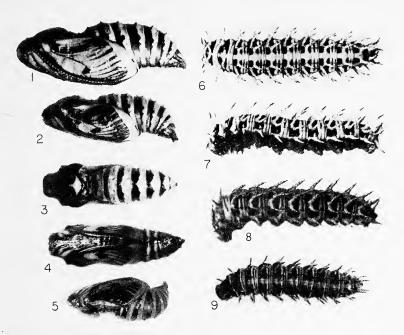
#### Introduction

Comstock (1928, 1940) and Skinner (1907) briefly described the egg, and young larva of *nokomis*, but not older larvae or pupae. This paper describes and illustrates the egg, larval, and pupal stages.

Early stages are based on several hundred eggs, larvae, and pupae reared from eggs laid by females from Elko County, Nevada (S. n. apacheana (Skinner)), Taos and San Juan Counties, New Mexico, the White Mountains of Arizona (S. n. nokomis (Edwards)), and Durango and Chihuahua states Mexico (S. n. coerulescens (Holland)). About 100 larvae were preserved from San Juan County, New Mexico (in J. Scott coll.), 10 or less from each of the other sites (in S. Mattoon coll.). Larvae were reared on Viola, including V. nephrophylla.

## Early Stages Description

Egg: Cream colored when laid, becoming tan after a few days. Strongly ribbed vertically, with ribs rising to several peaks surrounding the micropyle (Fig. 11). Numerous horizontal crossbars connect the vertical ribs. Incubation period is about ten days in the lab at about 20°C and constant light. Larva, Figs. 6-11: There are six instars. Head capsule widths average approximately 0.35, 0.6, 1.0, 1.4, 2.4 and 3.5 mm for the six instars, an average of 60% growth at each moult, based on measurements of about 50 New Mexico head capsules. The head capsule has a dark area after the first instar (Fig. 11); the dark area is black in later instars. Instars 1 and 2 are cream-colored mottled with brown, with a light dorsal band and a light lateral band running through the spiracles. Brown mottling occurs elsewhere especially on intersegmental membranes. Body darker around sclerotized areas. First instar brown mottling of S. n. coerulescens is very similar to that of ssp. nokomis. Setal pattern of all instars appears identical in these two ssp. (Fig. 10). Instars 3 and 4 are orangish cream (head pale orangish brown), with black spots and lines like instars 5 and 6, except



Figs. 1-5. Pupae. Figs. 6-9. Mature larvae. Figs. 1-4, 6-7, Chihuahua State, Mexico. Fig. 8, Taos County, New Mexico. Figs. 5, 9-11, San Juan County, New Mexico.

middorsal pale band whitish in color in instars 3-4. Mature (5-6) larva orangish ochre (head pale reddish brown) with black spots and lines (Figs. 6-9); middorsal pale band also orangish ochre. Mature larva has a light dorsal band on abdomen, a lateral light band just ventral to spiracles. Scoli brown in color with black tips, although dorsal side of two lateral rows of scoli cream in color, subdorsal scoli cream on prothorax and 9th abdominal segment scoli dark brown. Dark brown patches occur around scoli. Two transverse black bands occur behind scoli on dorsum of most segments.

A difference was noted between populations in the color pattern of later instar larvae. Instars 3-6 of ssp. *nokomis* (from New Mexico and Arizona), and *apacheana* have ground color orangish ochre, whereas ground color of *coerulescens* larvae is light yellow.

Pupa: Pupa orangish ochre with black markings (Figs. 1-5). The extent of black varies especially on the wing cases. Pupae of ssp. nokomis are fairly dark, with wing cases mostly black (Fig. 5). Pupae of White Mountains, Arizona nokomis, and apacheana, are lighter, with lighter wing cases. Pupae of coerulescens (Fig. 1) are still lighter, with predominantly light wing cases (although some individuals are dark, Fig. 2) and the abdomen is somewhat lighter also.

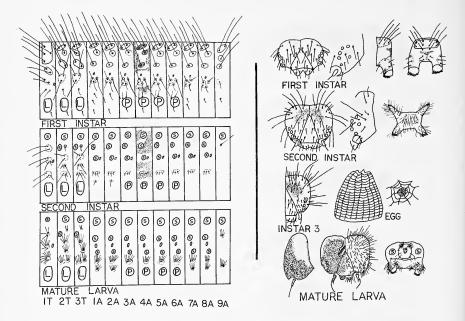


Fig. 10. Setal maps of larvae. Solid lines surround legs (L), prolegs (P), scoli (S), or sclerotized areas. Dash lines surround less well sclerotized areas. Small ovals on 1T (T = thorax) and 1-8A (A = abdomen) are spiracles. Stippling on first and second instar shows dark pattern of a typical segment.

Fig. 11. Head capsules of first, second, third, and mature larva, including view of left side of first, second, mature larva; terminal segments of first (lateral and posterior view), second, and mature larva; and egg (side view and dorsal view of micropyle). Stippling indicates dark areas; setae and color pattern of mature larva head is drawn on opposite sides of the head capsule.

## Developmental Period and Male-Female Emergence Lag

Developmental period from oviposition to emergence of adults is 61 days for males, 69 days for females, indoors at about 20°C for ssp. nokomis, a difference of 8 days. However, the lab is much warmer on average than nature, so development is probably longer in nature. Because first stage larvae overwinter and adults fly mainly from late July to September, it is reasonable to estimate a 4 month developmental period in nature for females. With a 4 month or 122 day developmental time, the 8 days increases to a 14 day difference between male and female emergence in nature (8/69 = 14/122). Males precede females in emergence in most insects. S. nokomis males may appear in late July or early in August, but females normally appear much later in mid or late August. Scott (1977)

demonstrated mathematically that male butterflies (and most invertebrates) should precede females in emergence; he showed that females should emerge when males are most abundant (which is later than when most males emerge) in order to maximize the number of matings for males and minimize the time required for females to find a mate. This is the evolutionary explanation for males preceding females in emergence. The lag is implemented physiologically by the longer developmental time for females just noted. Scott (1977) noted that the most important factors influencing the optimum length of the lag in emergence are lifespan of males and standard deviation (spread) of emergence time of males, and that the lag should be small only if females mate often. A reviewer suggests that emergence lags occur because "females are larger than males necessitating a longer feeding period. Also, females must accumulate the proteins and lipids that will be used for egg production." Actually, the large size of females is a consequence of their longer feeding period, not vice versa. Also, Ronald Rutowski (pers. comm.) found that in Pieris protodice Bd. & LeC., larger males produce larger spermatophores (which are digested by females and used for producing eggs) and females prefer to mate with larger males. So, according to these findings there are quite valid reasons why males should feed longer to grow to large size (they mate more often when larger and their mates produce more eggs). Furthermore, it is not clear that females should be larger, because a small female would use less energy in flight so would have more energy available for producing eggs, and a given size of female could produce more offspring merely by producing smaller eggs. Plus, larger males might fly farther and mate with more females, and the larger spermatophores produced by larger males stretch the female's bursa copulatrix more and are digested slower so the female will remate later. Of course, thousands of species of Lycaenidae exist very well with small sized females. The essential point of this discussion is that there are clear and obvious reasons why males precede females in emergence, which have been independently verified by Wiklund and Fagerstrom (1977), whereas it is not at all clear whether females should be smaller or larger than males.

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# Supernumerary Chromosomes in the Domesticated Eri-Silkmoth, Philosamia ricini (Saturnidae: Lepidoptera)

K. B. Padhy and B. Nayak

Department of Zoology, Bonaigarh College, Sundergarh, Orissa, INDIA

Abstract. Supernumerary chromosomes were detected in spermatocytes of the domesticated silkmoth, *P. ricini*. The supernumeraries varied from one to four in number and occupied an extranuclear position. In cases of single supernumeraries in a cell, it passes to one pole during anaphase I. Where two supernumeraries were present they form a bivalent in metaphase I and pass to two different poles during the next anaphase. All supernumeraries are eliminated from the meiotic cell population forming "micronucleus-like bodies" during interphase. Their "parasitic" way of chromatin elimination is discussed.

Microchromosomes occurring as supernumerary elements in the karyotype of lepidopteran species have been reported by many workers (DeLesse, 1960; Bigger, 1977; Nayal, 1974, 1978). Philosamia ricini possess a haploid chromosome number (n = 14) in the germ line. While examining the chromosome preparations of the testes from a population of domesticated P. ricini from Orissa, it was observed that in addition to the normal 14 bivalents in the diplotene and metaphase I, about 4% of the primary spermatocytes revealed 1-4 minute chromosomes which are supernumerary elements. The spermatocytes possessing supernumeraries showed their number as 1, 2 or 4. When they were more than one in number, pairing could occur between two such supernumerary chromosomes. A third supernumerary, if present, remained an univalent. All supernumeraries observed appear to be negatively heteropycnotic in metaphase I and positively heteropycnotic in the interphase. Therefore, such elements must not have produced by precocious resolution of any of the bivalents into univalents, nor to breakage of the normal complements, since they occur along with the normal chromosome complement. They have been observed to occupy a position outside the metaphase plate (Fig. 1), similar to such elements described by DeLesse (1960). Furthermore, missegregation of supernumeraries were observed in anaphase I when they numbered more than one, and when one supernumerary occurred it passed unresolved to one pole only. At the telophase I and the interphase they occupied an extranuclear position, forming a micronucleus-like body. They may be eliminated during germ cell development, therefore, without



Fig. 1. First metaphase spermatocyte of *P. ricini* indicating 14 bivalents and the supernumerary chromosome bivalent placed in an extranuclear position (arrow).

playing any significant role in influencing the development of the organism.

Although the exact nature of such supernumeraries is not yet known, these elements may represent a case of chromatinic elimination through heterochromatinisation of specific segments of normal bivalents. White (1977) argues that the presence of supernumerary chromosomes in many natural populations of insects may be produced due to metabolic disorders induced by agriculture chemicals. Such an explanation is not apparent here, since the species is maintained under laboratory conditions. Rather their both heteropycnotic and possibly deleterious nature more probably permits their classification as a "deleterious parasite" as suggested by Ostergreen (1945).

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# Geographic Variation and Ecology of Hesperia leonardus (Hesperiidae)

James A. Scott and Ray E. Stanford

60 Estes Street, Lakewood, Colorado 80226 and 720 Fairfax Street, Denver, Colorado 80220

Abstract. The systematics of the eastern members of the Hesperia leonardus complex are studied. H. l. leonardus and H. l. pawnee are conspecific and intergrade in Minnesota, Wisconsin and elsewhere, where extremely variable populations exist. The name H. l. montana is restricted to a recently rediscovered third subspecies occupying a small area in the Colorado mountains. H. l. montana is also extremely variable and is similar in several characteristics to Minnesota intergrade specimens. We summarize what is known about distribution, flight periods, habitat, adult behavior and foodplants of the leonardus complex. Adults have one brood (mostly August-September), and western populations feed mainly on Liatris flowers. Larvae eat various grasses, and hibernate in the first stage.

#### Introduction

MacNeill (1964) defined the *H. leonardus* group to include two western species (columbia Scudder and pahaska Leussler) which he studied in detail, and two eastern entities not studied in detail, pawnee and leonardus. The purpose of this paper is to study the taxonomic relationships of the latter two entities and to summarize what is known of their variation, distribution, behavior and early stages. The most interesting feature of the complex is that the eastern members pawnee and leonardus, appear to belong to one species, despite the gross color difference between them. Because of the importance of this conspecificity, the evidence for it is presented first.

## Conspecificity of leonardus and pawnee

There are several reasons why we combine *leonardus* and *pawnee* into one species. Pupae are the same (Scott, 1975b; Dethier, 1948). Larvae are the same although *H. l. pawnee* heads are lighter than those of *H. l. leonardus* and *H. l. montana* (Scott, 1975b). Scudder's (1889) drawings of first instar *leonardus* leave out many setae which occur in all known *Hesperia* species, and the long lateral setae on the ninth abdominal

segment in his drawing is probably a short spatulate seta as in all other known *Hesperia* (Dethier, 1939; Scott, 1975b). Eggs are very similar (Scott, 1975b) (the egg figured by Scudder (1889) is again poorly drawn). There are no differences in male or female genitalia which we can detect. Genitalia are too variable individually to detect differences; the genitalia drawings of *pawnee* and *leonardus* by MacNeill (1964) are not "typical". There may be slight interpopulational differences in antennal shaft length, the number of segments of the antennal shaft, and the length of the male penultimate tarsal segment, but these characteristics are also variable. Flight periods and adult behavior are very similar.

The main differences between populations of *leonardus* involve color pattern of palpi, body and wings. Superficially populations and individuals look very different from one another (Figs. 2-5).

H. l. leonardus and H. l. pawnee apparently intergrade over a broad area from Minnesota and Wisconsin to Manitoba and perhaps Iowa (Fig. 1). In Spruce Woods Forest in southern Manitoba individuals resemble pawnee but often have a rust tinge to the ventral yellow color, especially in females (Figs. 2-3). Four males from Sandilands in southeastern Manitoba are like Ontario H. l. leonardus except the dorsal surface is a little lighter, and the ventral hindwing spots are small. Samples of H. l. leonardus from Crivitz, Wisconsin are odd in several respects and several characters tend in the direction of pawnee (Figs. 2-3). Northwestern Wisconsin samples are intermediate to H. l. pawnee and H. l. leonardus. Of the two males from Des Moines, Iowa (Carnegie Museum), "one of these is quite like eastern leonardus, the other is somewhat paler, more fulvous, suggests transition to pawnee, but still mostly like leonardus" (H. K. Clench, pers. comm.).

The central Minnesota population is extremely variable in every wing character, varying from nearly "typical" pawnee to nearly "typical" leonardus in every character. The few structural characters such as antennal shaft length to head width ratio are also variable and are intermediate between the two subspecies.

If there are no barriers to hybridization of *H. l. leonardus* and *H. l. pawnee*, mating should be random and after several generations nonlinked genes should be independently combined in offspring. If major barriers to hybridization occur, however, or hybrids are largely sterile, the population should consist of a majority of individuals recognizable as either *H. l. leonardus* or *H. l. pawnee* plus a minority of individuals with hybrid traits. The evidence strongly suggests the first interpretation for the central Minnesota population.

In an effort to analyze differences between *H. l. leonardus* and *H. l. pawnee*, four male characters and five female characters were chosen for quantitative analysis. These characters were: (1) Ventral hindwing color (rated from 0 to 7 using eight standard reference specimens varying from light yellow to deep red brown). This color varies from yellow as in *H. l.* 

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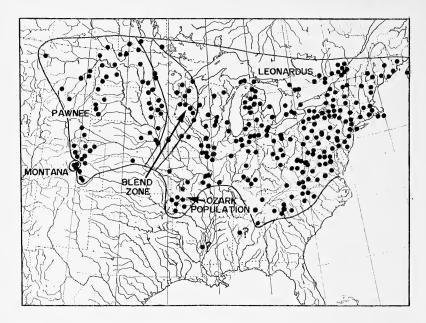
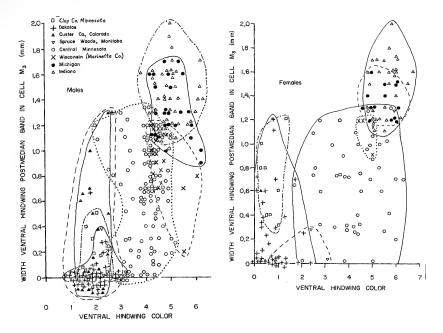
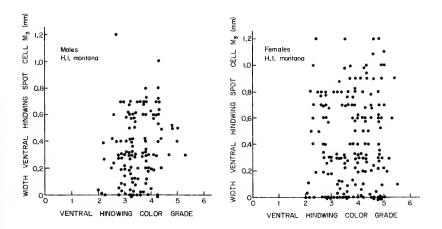


Fig. 1. Map of *H. leonardus* populations.

pawnee to red brown as in H. l. leonardus in both sexes (Figs. 2-3). (2) The width of the ventral hindwing postmedian band in cell M³. This band varies from 0 as in H. l. pawnee to 1.4 mm as in H. l. leonardus in both sexes (Figs. 2-3). (3) Dorsal lightness varies from dark reddish as in H. l. leonardus to light fulvous as in H. l. pawnee in both sexes. This character was quantified by use of five reference specimens. (4) Darkness of ventral forewing tornus. This varies from the ground color as in H. l. pawnee to completely black as in H. l. leonardus in both sexes. Five reference specimens were also used. (5) Transparency of the dorsal forewing hyaline spot. This character was used for females only. This spot varies from the ground color as in H. l. leonardus, to transparent as in H. l. pawnee. Four reference specimens were used to quantify this character. Characters 1-5 are very variable in the leonardus X pawnee blend zone, much more than in either H. l. leonardus or H. l. pawnee.

Characters 1-5 were plotted against each other (two of the 14 plots are shown, Figs. 2-5) in an effort to discover whether there was any reproductive isolation between *leonardus* and *pawnee* that would show up in wing pattern. No correlations were found except that there are very slight correlations in both sexes between dorsal lightness and darkness of the ventral forewing tornus, and in females (but not males) slight correlations appeared between ventral hindwing color and dorsal lightness and between ventral hindwing color and darkness of ventral forewing





Figs. 2-5. Scatter diagrams of width of ventral hindwing postmedian spot in cell M³ versus ventral hindwing color (0-pale yellow, to 6-dark rust red (for ssp. leonardus) or 6-dark brown (for ssp. montana)). Most ssp. are on Figs. 2-3, but ssp. montana is on Figs. 4-5.

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tornus. These correlations were very small however, and merely indicate that in some cases, especially in females, if one part of the wing is light another part is slightly likely to be light as well.

In general, however, these five characters which distinguish *H. l. leonardus* from *H. l. pawnee* are not correlated with each other. A typical Minnesota individual may have one character tending toward *H. l. leonardus*, another tendig toward *H. l. pawnee*, and others intermediate. It is our opinion that recombinations have occurred resulting in individuals with characteristics not observed in *H. l. pawnee* and *H. l. leonardus* populations. For example, some individuals have the ventral hindwing rust-red but with very small or no spots, and other individuals have this area light yellow with large spots (Figs. 2-3). This lack of correlation of characters and the lack of two clusters of individuals corresponding to the two parental types in any character suggests that the central Minnesota population is a freely interbreeding population. Due to fragmentation of natural habitat by farmland the central Minnesota colonies probably now receive little gene flow from either *H. l. leonardus* or *H. l. pawnee*, and variability is maintained as in *H. l. montana* through unknown mechanisms.

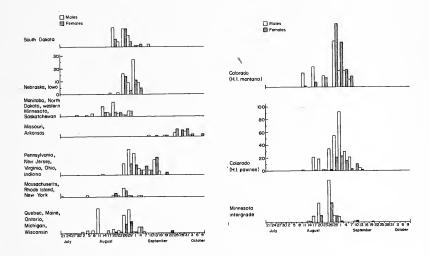
Males from Wabasha County, Minnesota in this intergradation area show variation similar to that of specimens from Anoka and Sherburne counties. Females, however, are slightly more similar to *H. l. leonardus* than are females from the latter two counties. Of 10 females examined, five are in the *leonardus* part of the Minnesota population scattergram (Fig. 3), while the other five are scattered but not in the *pawnee* corner of the plot.

## Flight Period, Habitat, Behavior and Larval Biology

The flight period of *H. leonardus* is very similar throughout the range: one brood, usually August to September (Figs. 6-7). Figures 6-7 clearly show that flight period is earlier at higher latitude and higher altitude. Ozark populations fly six weeks later than Canada populations, and plains *H. l. pawnee* flies later than mountain *H. l. montana*. Pittsburgh, Pennsylvania, inland populations fly several weeks earlier than those on the coast at Philadelphia.

*H. leonardus* populations all occur in meadows or grasslands, commonly old fields and moist meadows for *H. l. leonardus*, sandy prairie (near wooded areas) for the central Minnesota intergrade populations, prairie (sometimes sandy) for *H. l. pawnee*, and open grassy pine forest for *H. l. montana*.

Adult behavior of *leonardus* populations is very similar. All three subspecies and the intergrade populations are common at *Liatris punctata* flowers in Colorado, Nebraska, Minnesota, Michigan and New Jersey (occasionally on other flowers such as *Cirsium, Vernonia angustifolia, Eupatorium purpureum, Solidago, Clematis, Aster, other Liatris* species, "bonehead"). H. l. leonardus is usually found on flowers other than *Liatris*,



Figs. 6-7. Flight period for males and females, in three-day intervals.

H. l. leonardus foodplants are Agrostis (Scudder, 1893), Panicum virgatum and Eragrostis alba (Shapiro, 1966). Tietz (1972) lists a dicotyledon which cannot be a foodplant. Dethier (1939) and Scudder (1889) raised H. l. leonardus in the laboratory on common grasses. Many ovipositions of H. l. montana were seen on Bouteloua gracilis. We have not discovered oviposition substrate or foodplant for H. l. pawnee. A record of larval host of pawnee (1970 season's summary of the Lepidopterists' Society and Ferris, 1971) is erroneous because it is based on laboratory feeding of a dying larva. We raised H. l. montana and H. l. pawnee to adults (Scott, 1975b) on Poa pratensis, Cynodon dactylon and other unidentified

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grasses, and believe that laboratory hosts have little relevance to the plant used in nature by Hesperiinae, which may be host-specific in nature in spite of broad larval tolerance for laboratory grasses. Some *Hesperia* oviposit rather haphazardly, however (Scott, 1975a), so larvae may not be host-specific.

All *H. leonardus* populations must overwinter as young larvae, because eggs hatch immediately and there is not enough time before winter for the larvae to grow to large size. Overwintering occurs as first stage larva (ssp. *montana*), young larva (Scudder, 1893), first stage larva (Scudder, 1889), most first and some second stage larva (Dethier, 1939), second instar (Laurent, 1908) (all ssp. *leonardus*). When *H. l. leonardus*, *H. l. pawnee* and *H. l. montana* are raised indoors, no diapause occurs and adults emerge from November to January, taking only about three months to develop (Scott, 1975b).

### Taxonomy-H. l. leonardus

leonardus Harris, 1862. Ins. Inj. Veget., p. 314. Type locality: Boston, Mass.

lidia Plotz, 1883 (nomen dubium, dos Passos, 1964).

liberia Plotz, 1883 (synonym or nomen dubium; see dos Passos, 1960). stallingsi H. A. Freeman, 1943. Bull. Brooklyn Ent. Soc. 38: 153. Type locality: Blendon, Franklin Co., Ohio.

This subspecies occurs usually in open fields and damp meadows but occurs in permanently wet meadows and bogs in Virginia (Clark & Clark, 1951).

## Description

Apical FW spots distinct, ochre above and below. DFW basal color of females brown with a very slight orange flush. DFW spots of females distinct, fulvous, one or rarely two. VHW color light to dark rust red. VHW spots usually large (very rarely absent), ochre to white (more ochreous in males), median spot in cell  $SC + R^1$ , and median cell spot almost always present and round, spots larger in females. Fulvous DHW spots fairly distinct, moderate fulvous suffusion in males, little in females. VFW tornus almost always black, rarely little lighter than ground color.

Last instar larval head with a light V-shaped genal area and a lateral light area. Variation within H. leonardus leonardus is mostly clinal, with different characters showing different clines or patterns of variation (Table 1). There is essentially a north-south cline in wing size, with a peculiar small sample from Wisconsin. Dark dorsal phenotypes are prevalent on the Ozark Plateau and in the southeast; the most fulvous populations occur in Maine, Pennsylvania, Indiana and Wisconsin. The ventral hindwing band is smallest in the Ozark Plateau. This band is light in the Great Lakes region, and dark (ochraceous) in southern populations. Ventral hindwing color is dark in southern Great Lakes and middle Atlantic regions, lighter (ochreous) northward and westward. The Maine and Ozark samples, greatly different in other characters, are similar in ventral hindwing color. The independent variation of these characters in l. leonardus makes designation of additional

subspecies futile.

The Ozark sample is the most distinct. The Ozark material is larger, darker and tends to have the ventral hindwing spots reduced. The synonym stallingsi (Freeman, 1943) named from Franklin County, Ohio, falls about in the middle of the range of variation we have observed in H. l. leonardus.

### H. l. leonardus X H. l. pawnee

In central Minnesota there are extremely variable populations intermediate between the subspecies *leonardus* and *pawnee*. Its variation has already been discussed.

#### Description

Apical spots distinct, sometimes indistinct and usually ochre ventrally, sometimes white in females. DFW basal color of females moderately ochre to brown. DFW spots of females distinct, most fulvous, some hyaline, usually 1-3, rarely 4 spots. VHW color ochre yellow to light rust red. VHW spots large to obsolete, usually ochreous, median spot cell  $Sc+R^1$  often absent and median cell spot round but often small when macular band is present. Fulvous DHW spots in males sometimes fairly distinct but usually vague due to fulvous suffusion; in females with none to some fulvous suffusion. VFW tornus yellow to black, weakly correlated with ground color, slightly darker in females. Larvae undescribed.

#### H. l. pawnee (New combination)

Hesperia pawnee Dodge, 1874, Canad. Ent. 6:44. Type locality: Glencoe, Dodge County, Nebraska (type destroyed).

This light colored subspecies has evolved on the Great Plains. Another unrelated species, Hesperia ottoe Edwards, has convergently evolved similar appearance with light yellow underside, possibly for camouflage against a background of dried grasses. H. l. pawnee differs from H. l. leonardus mainly in the much lighter ochre color, the reduction of the ventral spots, and in having hyaline forewing spots in females; H. l. montana and the central Minnesota population are variable in the hyaline spot character perhaps due to hydbridization with pawnee. The hyaline spots apparently also evolve convergently on the plains. Of the Hesperia species which possess hyaline spots, H. ottoe, H. uncas Edwards (only plains and eastern Great Basin uncas have hyaline spots), H. dacotae Skinner, H. l. pawnee, H. metea Scudder, H. attalus Edwards, and some H. meskei Edwards, the first four are plains species.

There is considerable individual variation in some wing characters such as general dorsal color (very light to dark) and the number and size of faint ventral hindwing spots (variation noted also by Leussler, 1923). There is somewhat less variation in ventral color and in color of the female forewing spots. There is very little geographic variation throughout the range. A series from Custer County, Colorado, has slightly larger ventral hindwing ochreous spots (Figs. 2-3). Size decreases clinally from south to north as in H. l. leonardus (Table 2). Specimens from Montana are very small.

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		Ontario- Quebec	Maine	Massachusetts- Rhode Island	New York	Michigan	Wisconsin	Pennsylvania	New Jersey	0hio	Indiana	Virginia	Missouri- Arkansas
Sample	*0	6	15	6	7	28	19	5	22	2	41	. 4	10
size	0+	7	2	7	8	14	$\kappa$	0	16	8	30	2	23
Forewing	70	14.8	15.1	15.6	15.8	15.2	14.2	15.6	15.4	15.0	15.7	15.9	16.1
length (mm)	0+	16.1	16.5	16.5	17.0	16.0	15.6	;	16.5	16.2	16.9	17.5	17.1
Dorsal	*0	1.6	2.2	2.2	2.3	6.1	2.0	2.6	1.5	2.0	2.4	1.5	1.7
forewing fulvous (1-4)	0+	2.1	1.5	2.0	2.0	2.2	1	1	2.0	2.0	2.6	2.5	1.7
DHW band	*0	2.2	3.0	2.1	2.3	2.3	2.8	2.6	1.6	2.0	2.6	1.5	6.1
suffusion (1-4)	0+	2.0	1.5	2.0	2.0	2.0	1	1	2.1	2.0	2.3	2.0	1.6
VHW band	~	1.14	1.35	1.33	1.39	1.31	.92	1.28	1.37	1.35	1.43	1.32	1.18
width (mm)	0+	1.23	1.55	1.43	1.50	1.35	1	;	1.48	1.23	1.48	1.85	86.
VHW band	*0	6.1	2.7	2.7	2.8	2.3	2.6	2.4	2.7	2.0	2.9	3.0	3.0
color (1-4)	0+	2.1	3.0	2.4	3.0	2.4	;	;	2.4	2.7	2.8	3.0	3.0
VHW ground	~	4.84	4.85	44.4	4.89	5.02	4.67	4.74	5.64	5.65	5.03	5.35	4.29
color (0-7)	아	5.07	5.45	5.32	5.88	5.43	4.86	:	6.35	5.73	5.59	5.50	5.20
Table	٥i												
			,										
		H	H. 1. leonardus	mardus			Н.	H. l. pawnee					

		H. 1. leonardus	•			Н. 1.	H. l. pawnee				
		o u · · pamuee									H. l. montana
		Central Minnesota	Sask., W. Minn. Man. Montana	Sask., Man.	Montana	North Dakota	North Dakota South Dakota lowa	lowa	Nebraska	Nebraska Colorado	Colorado
Sample size	20	104	10	10	7	4	94	5	58	118	126
	0+	45	6	٣	0	σ	28	-	33	38	175
Forewing length	*0	15.3	16.2	15.0	14.5	15.1	15.5	15.5	15.8	16.0	15.3
	0+	16.6	17.6	17.0	1	16.7	17.3	17.0	17.5	17.4	16.8

Table 1. Geographic variation of six characters for H. leonardus leonardus: (1) forewing length in mm; (2) dorsal forewing fulvous (1-very little fulvous, 4-very fulvous, 2 and 3-intermediate); (3) dorsal hindwing postmedian band suffusion (1-narrow, discrete; 2-broad, still discrete; 3-intermediate; 4-suffused); (4) ventral hindwing postmedian band width in cell M3 (mm); (5) ventral hindwing postmedian band color (1-white; 2-very light ochre; 3-medium; 4-dark ochre); and (6) ventral hindwing ground color (0-very light yellow; 7-very dark rust red; 1 to 6-intermediate). Numbers (except for sample size) are averages.

Table 2. Forewing length (mm) of H. leonardus samples not included in Table 1.

#### Description

Apical spots rather indistinct and fulvous in males, distinct and hyaline in females. DFW basal color of females moderately ochre to brown. DFW spots of females distinct, most hyaline, usually 3-4, occasionally 2 spots. VHW color of males orangish ochre to ochre yellow, of females light ochre to ochre yellow. VHW spots same as in *montana* but spots usually obsolete, occasionally moderate size and ochreous, little lighter than rest of wing. Fulvous DHW spots same as in *montana*. VFW tornus usually yellow, rarely brown in males and black in females, slightly darker in females.

Larvae as in leonardus but heads are lighter laterally.

### H. l. montana (New combination)

Pamphila pawnee montana Skinner, 1911, Ent. News 22: 413. Type locality: we restrict to Buffalo Creek, Jefferson County, Colorado (the town).

H. l. montana differs from H. l. pawnee mainly in darker (more brown) color and the presence of ventral hindwing spots (Figs. 2-5). It is almost as variable as the Minnesota intergrade population.

## Description

Apical spots usually distinct, mostly fulvous, often hyaline in females. DFW basal color of females moderately ochre to brown. DFW spots of females distinct, fulvous to hyaline, most somewhat hyaline, usually 2-3, occasionally 1 or 4 spots. VHW color variable, ochre yellow to dark brown, rarely russet brown or greenish brown. VHW spots moderate size to obsolete, ochreous white, medial spot cell  $Sc+R^1$  rarely present, medial cell spot rounded, often absent, spots larger in females. Fulvous DHW spots fairly distinct, in females with slight to moderately fulvous suffusion, usually lost in fulvous suffusion in males. VFW tornus yellow to black, usually brown, weakly correlated with ground color, slightly darker in females.

Larvae similar to H. l. leonardus.

We designate a lectotype male in the Carnegie Museum, Pittsburgh, Pennsylvania (labels include "type no. 7086, Colorado Bruce, Chaffee Co. 7500 ft."), which fits the original description and our characterization of *H. l. montana*. Only two of the eleven cotypes had locality data: one says Chaffee County, Colorado 7500 ft. alt., and the other says Salida (Chaffee County, Colorado), May 21, 7500 ft. alt. These

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data are erroneous because H. leonardus adults almost never occur before August, the habitat at Salida differs from known habitats, and we have not found the species in Chaffee County in any month despite heavy collecting by James Scott and Glenn Scott (1978). F. M. Brown (pers. comm.) has determined the itinerary of David Bruce, based on letters from Bruce to Herman Strecker. The Chaffee County specimens are obviously mislabeled, because at the time they were collected, Bruce, a painter, was recuperating for three weeks from a fall from a scaffold, in a hospital in Redcloud, Nebraska! F. M. Brown found that Bruce had left a collecting net with the children of Mr. William W. G. Smith at Buffalo Creek, Jefferson County, Colorado, that August, who on 7 September sent Bruce 7 boxes of butterflies from the "Platte Canyon Valley." It seems probable that the Smith children caught the types of montana at or near Buffalo Creek. We correct and restrict the type locality to the vicinity of the town of Buffalo Creek, Jefferson County, Colorado, because of these historical records, and because we have found montana within several miles of there in August. D. Bruce mislabeled other butterflies (see Ferris & Fisher, 1977), and E. Oslar is similarly noted for mislabeling of material (Oslar specimens in the American Museum of Natural History).

H. l. montana occurs only in a small area in the South Platte River Canyon system in the mountains of Colorado. All the records of H. l. montana are in the Pikes Peak Granite, which occurs in the South Platte Canyon southeastward to Pikes Peak. H. l. pawnee does not occur on this granite and the granite boundary coincides with the boundary between montana and pawnee. H. l. montana is extremely variable (Figs. 4-5); some specimens are identical to plains pawnee and others are brown and have large cream spots on VHW. The ventral hindwing color ranges from yellow to dark brown, usually light brown, with occasional individuals greenish brown or slightly rust brown. In VHW color it is somewhat less variable than the central Minnesota population, but other wing characters are nearly as variable, and show the same lack of correlation as in the central Minnesota population. The variability seems to indicate gene flow from plains H. l. pawnee, although we could not find any intervening population between pawnee from Waterton and montana from the abandoned South Platte Hotel.

The wing pattern differences between H. l. montana and H. l. pawnee are genetic, because the differences were maintained in individuals raised under identical laboratory conditions.

There are three hypotheses for the origin of *H. l. montana*: 1) introgression of a pawnee population with Hesperia pahaska; 2) a relict population from a time in the Pleistocene when H. l. leonardus occurred in forested areas across what is now the Great Plains and when H. l. pawnee was farther south or had not yet evolved; 3) a population which evolved in its present location from H. l. pawnee founders. The first hypothesis, introgression, is supported by the several characters in which H. l. montana is more similar to H. pahaska than to H. l. pawnee, and by the flight periods. On the plains the flight periods of H. pahaska and H. l. pawnee are well separated, but in the mountains H. l. montana flies about a week earlier, so that late female pahaska might mate with early male montana. On July 2 we found H. pahaska males hilltopping on hills 200 feet from a later large concentration of H. l. montana, but the H. pahaska did not differ from specimens found elsewhere in eastern Colorado. In view of the difficulty in proving introgression, hypothesis one must be considered unsupported speculation. In morphology, H. leonardus is most

closely related to H. columbia which occurs on the pacific Coast. It is less closely related to H. pahaska, which is sympatric with H. l. montana and H. l. pawnee in numerous localities from Colorado to the Dakotas and Montana, but flies in June-July. There is no evidence to suggest that H. leonardus and H. pahaska hybridize anywhere that they meet, as we previously speculated (MacNeill, 1975). We believe that some combination of hypotheses two and three represents the probable history of the population. Hypothesis two is supported by the lack of dark ventral hindwing phenotypes in the present H. l. pawnee population to act as a starting point for selection of a darker population. However, H. l. leonardus has rust-red ventral coloration whereas in l. montana color variation involves various shades of brown and light rust individuals are rare. If hypothesis two is correct, since H. l. pawnee invervened between l. leonardus and l. montana the latter two populations may have diverged in ventral coloration. Hypothesis three is supported by the fact that both forest subspecies (leonardus and montana) are dark, whereas the plains subspecies (pawnee) is light. The variability of the color pattern of the wings of H. l. montana is hard to explain, but could be accounted for by selection for dark spotted phenotypes along with occasional immigration of H. l. pawnee phenotypes.

#### Distribution

Distribution is plotted on Figure 1. Flight periods are shown in Figures 6-7. Localities are listed below. H. l. leonardus undoubtedly occurs in Delaware and may be found in eastern Oklahoma. H. l. leonardus x pawnee may be found in central Iowa, southeastern Nebraska and northeastern Kansas. H. l. pawnee may be found in southeastern Alberta. The absence of H. l. pawnee records in the center of its range is probably due to lack of collecting.

Several records appear erroneous and are not listed. These include many for *H. l. montana* (see text above); *H. l. leonardus* from Florida (Scudder, 1889) which, judging from the flight period given, refers to *Hesperia attalus* (Edwards); and "Texas" (Evans, 1955). The records for Louisiana and Alabama are so isolated from other records that they require confirmation.

H. leonardus leonardus (counties only for U. S.) 164 males, 107 females examined

Nova Scotia: Digby.

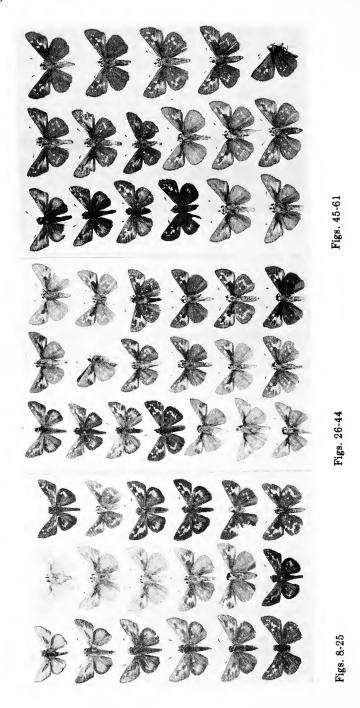
Quebec: Montreal, Terrebonne, Aylmer, Lakefield, Norway Bay, Shawbridge, Lanoraie, St. Anne de Bellevue, Rawdon, St. Maurice, Rigaud, Papineau Co., Gatineau Co., Pontiac Co.

New Brunswick: southern part.

Ontario: Perth Rd., Frontenac Co.; Bruce Co.; Clarendon; Chaffey's Locks, Leeds Co.; Kent Bridge, Kent Co.; Kahshee Lake, Muskoka Distr.; Asperitos Id., Parry Sound Distr.; Gravenhorst, Muskoka Distr.; Georgian Bay; Ottawa; London; Dublin; Toronto; Simcoe; Bruce Co.; Algonquin Park, Parry Sound Distr.

Maine: Penobscot, Cumberland, Lincoln, York, Hancock, Washington, Somerset, Franklin.

New Hampshire: Coos; White Mts.; Mast Yard.



- Figs. 8-25. H. leonardus pawnee (Figs. 8-18) and H. l. leonardus (Figs. 19-25). Ssp. pawnee: left column (top to bottom): m ups (upperside) Green Mtn., Jefferson Co., CO, 25 Aug. 1971, J. Scott; m ups same data; m ups Green Mtn., 4 Sept. 1969, J. Scott; fups 3 mi. S. Sedalia, Douglas Co., CO, 3 Sept. 1967, R. Stanford; f ups Lakewood, CO, 3 Sept. 1960, J. Scott; fups Little Missouri River, Billings Co., ND, 22 July 1970, J. Nordin; middle column: m und (underside) (ventral hindwing color no. 1) Green Mtn., 25 Aug. 1971, J. Scott; m und 3 mi. E. Wetmore, Custer Co., CO, 2 Sept. 1971, J. Scott; f und 3 mi. S. Sedalia, 3 Sept. 1967, R. Stanford; f und 1 mi. E. Parker, Douglas Co., CO, 11 Sept. 1968, R. Stanford; fund 1/2 mi. W. Bitter Lake, Day Co., SD, 25 Aug. 1971, J. Nordin; ssp. leonardus: m ups near N. Manchester, Kosciusko Co., IN, 27 Aug. 1970, E. M. Shull; right column: m ups Eggleston, VA, 26 Aug. 1964, G. Straley; m und Enfield, ME, 26 Aug. 1964, L. Grey; f ups near N. Manchester, 2 Sept. 1970, E. Shull; f ups Ida Center Rd., Monroe Co., MI, 28 Aug. 1971, L. Melton; fund near Woodbine, Cape May, NJ, 12 Sept. 1970, R. Stanford; f und Eggleston, 14 Sept. 1964, G. Straley.
- Figs. 26-44. H. leonardus leonardus x leonardus pawnee, all from Sand Dunes State Forest, Sherburne Co., Minnesota. Left column: m ups 31 Aug. 1966, C. Hansen; m ups, 18 Aug. 1967, P. Nordin; f ups 29 Aug. 1971, J. Masters; f ups 19 Aug. 1967, P. Nordin; m und 19 Aug. 1967, P. Nordin; m und (ventral hindwing color rating no. 2), 19 Aug. 1967, P. Nordin; m und 31 Aug. 1966, C. Hansen; middle column: m und (color rating no. 4), 16 Aug. 1970, J. Nordin; m und (color rating no. 3), 29 Aug. 1971, J. Masters; m und 19 Aug. 1967, P. Nordin; m und 19 Aug. 1967, P. Nordin; f und 29 Aug. 1971, J. Masters; f und 25 Aug. 1969, J. Sorensen; f und 19 Aug. 1967, P. Nordin; f und 25 Aug. 1969, J. Sorensen; f und (color rating no. 6), 19 Aug. 1967, P. Nordin.
- Figs. 45-61. H. leonardus montana, all J. Scott. Left column (top to bottom): m ups N. of Cheesman Lake, Jefferson Co., CO, 3 Sept. 1971; m ups Nighthawk, Douglas Co., CO, 28 Aug. 1969; fups Nighthawk, 1 Sept. 1970; f ups Nighthawk, 1 Sept. 1970; m und Nighthawk, 12 Aug. 1971; m und Nighthawk, 29 Aug. 1971; middle column: m und Nighthawk, 12 Aug. 1971; m und Nighthawk, 28 Aug. 1969; m und Nighthawk, 1 Sept. 1970; f und (ventral hindwing color rating no. 2), Nighthawk, 28 Aug. 1969; f und Nighthawk, 29 Aug. 1971; f und Nighthawk, 28 Aug. 1969; right column: f und Nighthawk, 1 Sept. 1970; f und Nighthawk, 28 Aug. 1969; f und Nighthawk, 28 Aug. 1969; f und Nighthawk, 28 Aug. 1969; f und Nighthawk, 1 Sept. 1970; f und (color rating no. 5), N. of Cheesman Lake, 3 Sept. 1971.

Vermont: Windham.

Massachusetts: Barnstable, Nantucket, Essex, Middlesex, Bristol, Dukes, Worcester; Harwich Point; Pelham Hills; Hallowell (in Mass.?).

New Jersey: Camden, Ocean, Cape May, Middlesex, Burlington, Mercer,

Bergen, Union.

Rhode Island: Providence, Washington.

Connecticut: Hartford.

New York: Richmond, Nassau, Suffolk, St. Lawrence, Clinton, Jefferson, Essex, Lewis, Oswego, Hamilton, Warren, Washington, Fulton, Oneida, Albany, Schoharie, Columbia, Onondaga, Genesee, Erie, Livingston, Chautauqua, Cattaraugus, Allegany, Steuben, Yates, Cayuga, Seneca, Schuyler, Chemung, Tompkins, Tioga, Broome, Chenango, Delaware, Sullivan, Ulster, Orange, Dutchess, Rockland, Westchester, Greene.

Pennsylvania: Allegheny, Bucks, Butler, Chester, Clarion, Crawford, Delaware, Fayette, Montgomery, Montour, Lancaster, Somerset, Warren, Westmoreland, Bedford, Indiana, Schuylkill, Tioga, Susquehanna, Berks, Lackawanna, Monroe, Pike, Clinton, Potter, Centre.

Maryland: Montgomery, Garrett, Baltimore, Allegheny, Prince Georges, Charles, Ann Arundel.

District of Columbia: Washington.

Virginia: Arlington, Patrick, Madison, Giles, Montgomery, Prince William, Stafford, Powhatan.

West Virginia: Kanawha, Randolph, Nicholas, Upshur, Lewis.

North Carolina: Durham, Richmond, Buncombe, Avery, Guilford, Clay, Transvlvania.

South Carolina: Greenville.

Georgia: Rabun.

Alabama: Cherokee, Tuscaloosa. Louisiana: Madison Parish. Tennessee: Morgan, Marion.

Kentucky: Larue, Jefferson, Meade.

Ohio: Franklin, Lorain, Athens, Lucas, Williams, Hocking, Jackson, Wayne, Ashland, Vinton.

Indiana: Perry, Brown, Lake, Randolph, Wabash, Kosciusko, LaGrange, Porter, Steuben, Pulaski.

Illinois: Vermilion, Mason, Cook, Peoria, McDonough, Jackson, Mason, Hancock, Schuyler.

Michigan: Monroe, Newaygo, Iosco, Allegan, Montçalm, Kalamazoo, Chippewa, Livingston, Houghton, Otsego, Oakland, Macomb, Grand Traverse, Presque Isle, Schoolcraft, Emmet, Cheboygan, Kalkaska, Crawford, Oscoda, Manistee, Roscommon, Ogemaw, Lake, Osceola, Mecosta, Huron, Ottawa, Kent, Clinton, St. Claire, Ingham, Jackson, Washtenaw, Wayne, Berrian, Brown, Van Buren, Dickinson.

Arkansas: Benton, Washington, Carroll, Ovachita.

Missouri: St. Louis, Iron, Camden, Barry, Greene, Franklin, Jefferson, St. Francois.

Kansas: Douglas.

Iowa: Scott, Des Moines, Polk, Audubon?, Winneshiek.

Wisconsin: Marinette, Eau Claire, Grant, Langlade, Milwaukee, Green, Sauk, Dane, Columbia.

Manitoba: Sandilands.

# H. l. leonardus x H. l. pawnee (counties and localities)

121 males, 55 females examined

Wisconsin: Douglas (Dairyland, Jackson L. Boughner); Burnett (Crex Meadows near Grantsburg, J. L. Boughner).

Minnesota: Sherburne (Sand Dunes State Forest SSE Orrock and near Zimmerman, J. S. Nordin, P. D. Nordin, C. Hansen, J. Masters, J. T. Sorenson, W. Bergman); Anoka (Section 11, Coon Rapids Township, J. S. Nordin; Bunker Prairie, R. L. Huber); Wabasha (Kellogg, Allison Bolduc, Gary Korsmo; Kellogg Prairie, R. L. Huber); Goodhue (Eggleston, E. M. Brackney); Chisago (2 mi. N. Chisago City); Crow Wing (Brainard); Olmstead; Scott; Dakota.

H. leonardus pawnee (counties only for U. S.)

409 males, 139 females examined

Minnesota: Lac Qui Parle, Murray, Yellow Medicine, Chippewa, Pipestone, Clay, Lincoln, Norman, Swift.

Iowa: Poweshiek?, Woodbury.

Kansas: Smith.

Nebraska: Stanton, Boone, Dodge, Nemaha, Douglas.

South Dakota: Day, Meade, Harding, Pennington, Custer, Lawrence, Brookings, Marshall, Roberts.

North Dakota: Ransom, Bottineau, Williams, McKenzie, Morton, Grand Forks, Billings, Ramsey, Slope.

Manitoba: Aweme, Cartwright, Spruce Woods Forest Reserve near Hwy. 258. Saskatchewan: Redvers.

Montana: Dawson, Custer, Big Horn, Prairie, Chouteau.

Wyoming: Platte, Sheridan, Laramie.

Colorado: Logan, Larimer, Weld, Boulder, Denver, Arapahoe, Jefferson, Douglas, El Paso, Custer, Pueblo, Morgan.

H. leonardus montana (counties and localities) 208 males, 239 females examined

Colorado: Douglas Co.: Sugar Creek 5 mi. NE Deckers (R. E. Stanford), Nighthawk 10 mi. NE Deckers, 4.3 mi. SE Deckers, 10 mi. SSE Deckers (all three J. A. Scott); Teller Co.: junction of Teller, Douglas, Jefferson, and Park Counties (R. E. Stanford); Jefferson Co.: 1 mi. N Cheesman Reservoir near Wigwam Creek (J. A. Scott), 6.9 rd. mi. up North Fork of South Platte River from town of South Platte (J. A. Scott), South Platte Hotel (R. E. Stanford & J. A. Scott), Deckers (R. E. Stanford).

## Summary

Hesperia leonardus Harris, 1862

- a. leonardus leonardus Harris, 1862
  ? liberia Plotz, 1883 (nomen dubium, dos Passos, 1960)
  ? lidia Plotz, 1883 (nomen dubium, dos Passos, 1964)
  stallingsi Freeman, 1943 (subjective synonym)
- b. leonardus leonardus x leonardus pawnee (intergrade populations)
- c. leonardus pawnee Dodge, 1874 (new combination)
- d. leonardus montana (Skinner) 1911 (new combination)
   Type locality correction and restriction: town of Buffalo Creek,

Jefferson County, Colorado. Lectotype designated Carnegie Museum.

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## Notes on the Immature Biology of Two Myrmecophilous Lycaenidae: Juditha molpe (Riodininae) and Panthiades bitias (Lycaeninae)

Curtis J. Callaghan<sup>1</sup>

Apartado Aereo 2184, Cali, Colombia

Abstract. The early stages, habitat, and biology are described for two sympatric lycaenid butterflies, *Juditha molpe* (Riodininae) and *Panthiades bitias* (Lycaeninae). The larvae of both species use the same foodplant and are tended by ants of the genus *Campanotus*.

#### Introduction

Juditha molpe (Huebner) is a common riodinid butterfly of the neotropical region ranging from Mexico to Argentina and inhabiting a wide variety of habitats from rainforest to dry tropical scrub. Guppy (1904) recorded molpe larvae as feeding on Cassia plants and found in association with "large solitary ants" in Trinidad. His description of the larvae and their interaction with the ants is very sketchy, however. He merely mentions that the ants attend and milk the larvae.

Panthiades bitias (Cramer) is a common hairstreak butterfly of the neotropics, ranging from northwestern and central Mexico to central Brazil. In spite of its being found commonly throughout its range, its biology has not been described. A foodplant records is given in Muyshondt (1973).

The purpose of this paper is to describe the immatures, habitat, and biology of *J. molpe* and *P. bitias* as observed at El Boqueron, Colombia. This paper represents part of a continuing effort to study and record the biology of neotropical Lycaenidae.

## **Description of Immature Stages**

J. molpe

Egg: About 0.5 mm in diameter, slightly flattened above and below. Micropyle small and round, with a dot in the center. Color light green when laid, then turning to tan. Surface covered with a network of thin lines. Duration six days. First instar larva, Fig. A. Newly hatched larva 0.9 mm long. Head capsule width 0.2 mm. Head and thorax black, rest light green. Prothorax with eight small dorsal protrusions with a small seta

<sup>&</sup>lt;sup>1</sup>The author is "Pesquisador Associado" at the Museu Nacional, Rio de Janeior.

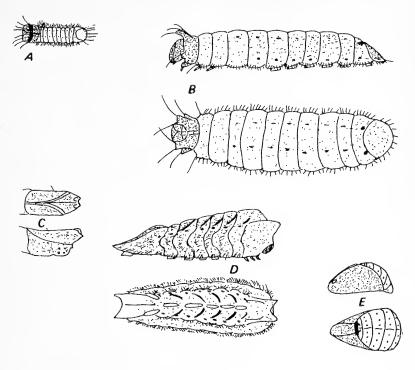


Figure A. First instar larva of *J. molpe*. Figure B. Fourth instar larva of *J. molpe*. Figure C. Cephalad part of pupa of *J. molpe*.

Figure D. Final instar of P. bitias.

Figure E. Pupa of P. bitias.

extending cephalad out of each. Abdomen with small yellow spiracles on the second through eighth segments, and a carapace on the last segment with numerous long setae extending from around its edge. All abdominal and the second and third thoracic segments with small setae bordering the lower edge. Third instar larva. Length 5 mm, head capsule width 0.8 mm. Head and prothorax black, rest pale yellow. Prothorax with two deeply bisected horns cephalad with one long seta on each lobe. Also, a smaller protrusion found on each side of the prothorax with two setae extending laterally out of each. Another seta extends laterally from the mesothorax. Abdomen as in first instar with the added presence of two raised myrmecphilous organs on the eighth segment. The setae at the end of the last abdominal segment shorter. Duration six days. Fourth instar larva: Fig. B. Length 7.5 to 14 mm. Head capsule width 1.5 mm. Head black. Prothorax light brown, rest olive green. Two rows of small yellow spots dorsally on the abdominal segments. Two myrmecophilous glands

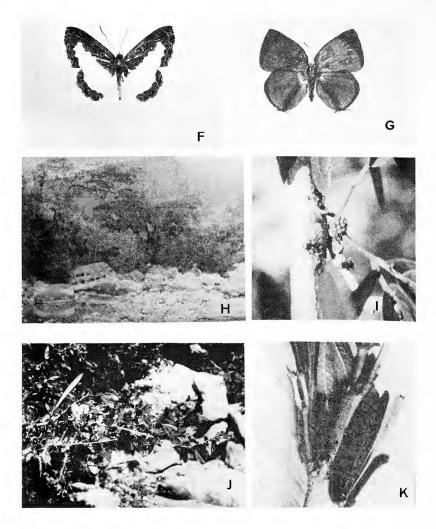


Figure F. Adult Juditha molpe.

Figure G. Adult Panthiades bitias.

Figure H. Habitat at El Boqueron, Colombia.

Figure I. Final instar Panthiades bitias attended by ants on foodplant.

Figure J. Foodplant Calliondra globerrima.

Figure K. Juditha molpe final instar attended by a Campanotus ant.

light brown. Prothoracic horns blunter and with two setae each. Second smaller horn on each side with one seta each. One additional seta on the mesothorax. Spiracles and myrmecophilous glands light brown. Duration eight days. Fifth instar larva: Fig. K. Length 15 to 19 mm. Head capsule

width 2 mm. Color light green and brown mottled. Morphology as in fourth instar. Duration eight days. **Prepupal larva**: Length 19 mm. Color light mottled brown. Duration three days. **Pupa**: Fig. C. Color light mottled brown with striated darker brown marks. Wing cases darker brown than abdomen. Attached by a thin girdle passing over the middle of the body and a silk pad under the last segment. **Imago**: Fig. F.

#### P. bitias

Third (?) instar larva: Length 5 mm, head capsule width 0.8 mm. Head black, rest light brown and green mottled. Head covered by a hood formed by the first thoracic segment. Second and third segments form a fleshy bifurcated proturbance extending over the first segment. Abdominal segments flat and slightly concave dorsally and convex laterally, giving the larva a hexagonal shape when viewed head on. Yellow spiracles found on segments one through eight dorsally. Last abdominal segments with a broad dorsal plate which is slightly concave at the end. Body covered with small cilia. Final instar larva: Figs. D & I. Head black, thorax and abdomen light brown and green. Abdomen with darker green elongated marks dorsally and two yellow marks on the sixth and seventh segments. Morphology similar to the third instar, only with the proturbance of the second thoracic segment and the plate of the abdominal segment being more deeply bifurcated. Duration nine days. Prepupal larva: Length 20 mm. Color light mottled brown. Morphology as in final instar. Duration two days. Pupa: Fig. E. Wing cases dark green, abdomen light green with three rows of small light brown dots on each side. Attached by silk pad. Imago: Fig. G.

#### Discussion

El Boqueron is a small town located on the border of the Departments of Cundinamarca and Tolima, some 80 km southwest of Bogota at an elevation of 300 m. Here, the boulder strewn Rio Chocho cuts through some high ridges on its way to the Magdalena River, forming a deep and rather picturesque canyon. The area is classified as Dry Tropical Forest (IGAC, 1977, after Holdridge, 1947), with an annual rainfall of between one and two meters. The rains usually fall in March through May, and again in September through November. The dry climate combined with repeated burnings have practically denuded the area of forest, except for thin lines of trees along the streams. The general aspect of the countryside is not unlike that of northern Mexico, with thorny scrub, cacti, and herbacious plants growing on the higher rocky ground (Fig. H). The butterfly fauna is likewise similar to that of the northern neotropics with species such as Heliconius charitonia, Zeonia cesonia and Libythea bachmanni found commonly following the rains.

The principal foodplant of both J. molpe and P. bitias at El Boqueron is Calliondra globerrima (Benth.) Britton & Killip, family Mimosacae. It

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grows commonly along the river bed and is sometimes covered by water during flash floods. Its appearance is that of a small bushy tree with small leathery pinnate leaves and clumps of red and white flowers with long stamens, which bloom at various times during the year (Fig. J). The fruits are elongated bean-like pods about 13 cm long with up to a dozen black seeds inside. This plant does not have extra-floral nectaries, but is often infested with coccids which attract ants of the genus *Campanotus*.

A second plant on which female J. molpe were observed ovipositing was Bauhinia pediolata (Mutis ex DC) Trioma ex Hook, family Caesolpinaceae. This shrub has large rounded, pointed leaves, clumps of yellow flowers, and long bean like fruits. Extra-floral nectaries, located on the stems between the fruits and flowers, attract the same Campanotus ants as those on C. globerrima. B. pediolata is a forest species, growing in more shaded localities than C. globerrima.

I observed J. molpe females ovipositing on both plants between 1200 and 1400 hours. The eggs were laid wherever there were ants, and not on any particular part of the plant. Strangely, I did not observe oviposition on the flowers of C. globerrima which is where the larvae feed. Eggs were laid singly, the female feeling the substrate with her abdomen before ovipositing. Nearby ants would make agressive movements in the form of short rushes towards the female, at which time she would fly off. Following one female, I observed six eggs placed on different widely spaced parts of C. globerrima in about ten minutes. I was unsuccessful in finding larvae on other nearby C. globerrima plants which were in bloom, but without ants. Also, ovipositing females showed little interest in these plants, sometimes investigating them, but always returning to the infested plant to oviposit. This behavior suggests that the main attractant to the ovipositing female molpe was the presence of ants, and not mere foodplant availability. This possibility is reinforced by my observations of oviposition on a completely unrelated plant, B. pediolata, but which harbored the same ant species. Future searches of B. pediolata failed to turn up larvae. In fact, B. pediolata leaves presented to the larvae in the lab were ignored in favor of C. globerrima flowers. No B. pediolata flowers were available during the time of the study to test the larvae preference for this part of the plant.

Upon hatching the small J. molpe larvae on C. globerrima move to nearby clumps of ripe flower buds where they begin to feed. Immature green buds, flowers and leaves are not eaten, the latter being especially tough and leathery. The young molpe larvae pass at least the first two instars inside the bud clumps in the company of small coccids and other insect larvae, possibly dipterids. The larvae lead a solitary existence, and although two or more were found on the same bud clump, they showed little interest in one another.

Upon reaching the third instar, both *J. molpe* and *P. bitias* leave the buds and move to nearby stems or leaves where they may remain motionless for

as long as 24 hours before returning to feed on the buds. When moving about the foodplant, both species weave the head back and forth, spinning a silk web with which they maintain their grip on the plant surface. Their mottled green color and flat profiles make both *molpe* and *bitias* difficult to locate on the foodplant. Their presence was usually betrayed by the ants which showed great interest in the larvae of both species at this stage (Figs. I & K). At least three ants were always observed in attendance, stroking or "drumming" on the larvae, which in turn would secrete honeydew which the ants would eat. The interactions observed between the ants and larvae were similar to those of *Menander felsina* and *Campanotus* ants studied near Rio de Janeiro (Callaghan, 1977).

The myrmecophilous organs of *J. molpe* are located on the eighth abdominal segment and take the form of two slightly raised lumps with a hole in the middle, looking like the nectaries on many plants. Unlike *M. felsina* larvae, there was no observed physiological change in the shape of the glands when stimulated by ants. Nor were there any organs similar to the lateral tubercles of *Lemonias caliginea* (Ross, 1966) or various species of *Audre* (Pers. Observation). The "horns" on the prothorax of *J. molpe* were observed to be passive organs, though the long setae protruding from each would suggest that they had a sensory role. When disturbed, the *J. molpe* larvae raise the front half of the body and flop it around, as do various species of *Actinote* (Pers. Observation).

The *P. bitias* larvae were equally attractive to ants. However, observation under magnification failed to reveal any distinct myrmecophilous organs. The interest shown by the ants in the dorsal plate covering the last abdominal segments suggests that the organs, perhaps very small, are located in that area (Fig. I). The *P. bitias* larvae did not respond vigorously when disturbed; instead, they would simply move slowly away. Malicky (1971) has described the presence of microscopic epidermal glandular organs which appear to secrete an ant attracting pheromone. These may not be associated with Newcomer's organ and the obvious "honeydew" secretions.

As in the case of felsina, the ants protect the larvae against predation. When I touched a larvae of either species with a stick, the ants became very excited, running about and exuding great quantities of formic acid which I could smell on my hands hours later. To eject the acid, however, these Campantus do not rise up on their hind legs as was observed in Brazil (Callaghan, 1977). The formic acid had no apparent effect on the larvae.

The only aggressive behaviour noted on the part of the larvae was the eating of a J. molpe pupa by two molpe larvae. The larvae had been without food for two days which I suspect was the reason for their action. This suggests that the molpe larvae may resort to cannibalism if their food supply fails.

Both molpe and bitias have a prepupal stage lasting two and three days

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respectively in which they stop feeding and remain motionless on the stem of the foodplant. They turn a mottled brown color, and, in the case of *bitias*, release a large amount of honeydew, no doubt attracting ants which may provide protection during this vulnerable stage. The larval skin is then shed and the pupal case hardens. In the case of *bitias*, the imago emerges about a month later.

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# Immature Stages of Odonna passiflorae Clarke (Lepidoptera: Oecophoridae): Biology and Morphology

Patricia Chacón

and

Marta de Hernandez

Departamento de Biologia, Universidad del Valle, Cali, Colombia

**Abstract.** This paper describes the larva and pupa of *Odonna passiflorae* Clarke (Lepidoptera: Oecophoridae), its host and natural enemies.

The feeding habits of Oecophoridae larvae are extremely varied. In Colombia, *Maesara gallegoi* Clarke was found boring into stumps and limbs of apple trees (*Malus* sp.), and *Inga* sp. and *Borkhausenia* sp. were found chewing on citrus and wheat seeds respectively (Posada *et al.*, 1976).

Odonna passiflorae Clarke was found on curuba (Passiflora mollissima Bailey) vines and has become an economically important plague for this crop.

#### **Methods and Materials**

This research was carried out at Tenerife, a small Colombian town located in the Andes at 2600 m. It has a temperature of 13.8°C and 81% Relative Humidity (RH).

Curuba was established as a crop in approximately 1960 in this area of Colombia and has become the most important source of income for many peasants. Extensive field observations were made from March 1980 to July 1981.

Adult individuals were obtained by rearing immature stages in the laboratory (in Cali, 1000 m, 20°C and 67% RH). Larvae were placed in plastic boxes (10 x 7 x 3.5 cm) containing 8-10 stem pieces (8 cm long) of curuba on top of a wet layer of sterile soil-sawdust mixture.

Descriptions of larval stages and nomenclature of setae are according to Peterson (1962).

#### Results

Description of the larva:

Body: 18-21 mm long, cream white with skin smooth; center of spiracles creamish, peritremes brown (Fig. 1a). Head: about 2.1 mm wide, yellowish brown, height of frons greater than length of epicranial

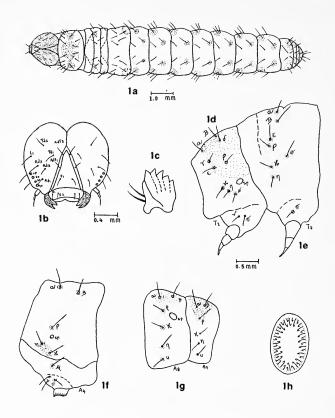


Fig. 1. a. Dorsal view of caterpillar; b. Frontal view of head capsule; c. Mandible;
d. Prothorax; e. Mesothorax; f. Fourth abdominal segment; g. Eight and ninth abdominal segment; h. Crochets biordinal circle.

suture; frons width less than its height; the fourth ocellus is much closer to the third than to the fifth, and the second is always farther from the first than the third; setae Adf² and Pd¹ at the same level; seta Ad² closer to Ad³ than to Ad¹ (Fig. 1b). Spinneret narrow and rounded apically; mandibles with five teeth (Fig. 1c). **Thorax:** Prespiracular group on the prothorax trisetose, distinctly separated from the cervical shield which is slightly dark dorsally; seta rho below seta delta; epsilon posteroventral to gamma; Pi group (subventral) bisetose (Fig. 1d). Mesothorax and metathorax with the seta beta directly below alpha; eta below kappa and Pi group unisetose (Fig. 1e). Prothoracic spiracle as large as 8th abdominal spiracle and larger than the others. **Abdomen:** setae eta and kappa adjacent, located below the spiracle (Fig. 1f). On 8th and 9th segments, the seta beta is closer to the dorsomeson than seta alpha (Fig. 1g). The prolegs are short and possess circles of biordinal crochets present on segments 3 to 6 (Fig. 1h).

Description of the pupa:

Obtected type; dark yellow, from 9.5 to 13.0 mm long; labrum simple; labial palpi concealed; without functional mandibles; fronto-clypeal suture obsolete in middle; antennae diverging at apex and reaching almost to the tip of wings; forewings not extending beyond the 4th abdominal segment; first 4 abdominal segments longer than the rest; epicranial suture not visible.

Host plant and feeding habits:

The larvae are gregarious. They feed on the main stem and limbs of curuba plants. The young larva bores into the inner bark of the vine and continues to the heartwood where it makes long tunnels and irregular galleries (Fig. 2). The larva maintains contact with the outside and expels large amounts of sawdust and frass that cling in masses on the bark.



Fig. 2. Injury to the trunk of *Passiflora mollissima* Bailey caused by the borer *Odonna passiflorae* Clarke.

Pupation occurs inside the trunk and the new adult emerges through the bark, leaving a shot-hole effect. Infestation may be recognized by wilted, off-color foliage and longtitudinal scars in the bark. The borer prefers old curub vines (6 years of age), but once the old plants are destroyed, they attack younger plants (+ 1 year of age).

Natural enemies:

The larval stage is attacked by a number of parasites, including wasps (Icheumonidae) and flies (Tachinidae). Also, disease causing microorganisms sometimes result in death of large numbers of borers. The fungus *Beauveria bassiana* has been isolated from dead and dying larvae. This pathogen has been recognized as an effective control agent.

Acknowledgments. We thank Drs. J. F. Gates Clarke and Goro Kuno for identifying the insect and pathogen respectively. Dr. Benjamin Jimenez criticized the manuscript. This work was supported by the Comite de Investigaciones of the Universidad del Valle.

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## A New Genus and two New Species of Oecophoridae from Colombia (Lepidoptera)

#### J. F. Gates Clarke

Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D. C. 20560

**Abstract.** The genus *Odonna* and the two species, *Odonna passiflorae* and *O. xenodora* are described as new and figured.

The first species, Odonna passiflorae, is described to provide a name for this moth which is a pest of Passiflora mollissima Bailey in Colombia. Because the second species, O. xenodora, collected over 20 years ago, was found to be congeneric with the first, it is included for completeness' sake.

The life history and descriptions of the early stages of *O. passiflorae* follow. Patricia Chacon de Ulloa and Marta Rojas Hernandez submitted the specimens of the adults to me for identification.

#### Odonna Clarke new genus.

**Type Species:** Odonna passiflorae, new species (by present designation). The gender of the generic name is feminine.

Labial palpus slender, recurved; third segment shorter than second, acute. Tongue well developed; maxillary palpus minute, appressed to base of tongue. Head rough, side tufts spreading; ocellus absent. Antenna simple, shorter than forewing; scape with pecten. Thorax smooth. Forewing smooth, costa nearly straight, termen oblique, 12 veins; 1b furcate; 1c strongly preserved; 2, 3, and 4 equidistant; 5 nearer to 4 than to 6; 7 and 8 stalked, 7 to apex; 10 much nearer to 9 than to 11; 11 from one-third of cell; upper internal vein absent; hindwing with 8 veins; 2 remote from 3; 3 and 4 short-stalked, 5 about equidistant from 4 and 6; 6 to termen slightly below apex; 6 and 7 subparallel. Hind tibia roughened with long scales. Abdominal terga not setose.

Male genitalia. Uncus and socius present; gnathos absent. Female genitalia. Signum absent.

I am unable to reconcile *Odonna* with any previously described genus. In my key to the Chilean genera (Clarke, 1971, p. 2) the present genus keys to *Talitha* Clarke, but in *Odonna* 3 and 4 of the hindwing are short-stalked; in *Talitha* 3 and 4 are widely separated. Furthermore, the female genitalia of the two genera are of quite different types. In *Talitha* the ductus bursae is long and coiled and the signum is present; in *Odonna* the ductus bursae is short, uncoiled and the signum is absent. In Meyrick's Key (1922, p. 3) this genus keys to the African *Ceranthes* Meyrick. In *Ceranthes* 3 and 4 of

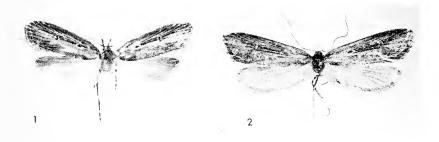


Fig. 1. Odonna passiflorae, n. sp. Holotype female.

Fig. 2. Odonna xenodora, n. sp. Holotype male.

forewing are approximate and 7 is to costa but in Odonna 3 and 4 are separate and 7 goes to apex. I have not seen the genitalia of Ceranthes.

### Odonna passiflorae Clarke new species.

Figures 1, 3, 5

Alar expanse 24-30 mm.

Labial palpus white profusely irrorate with fuscous. Antenna buff with grayish fuscous bars; scape fuscous. Head grayish fuscous. Thorax grayish fuscous, with some whitish scales posteriorly; tegula grayish fuscous, tipped with whitish scales. Forewing ground color buff but so heavily overlaid and streaked with fuscous that the ground is largely obscured; costa grayish fuscous mixed with white scales; veins streaked with fuscous; at basal fourth, in cell, a blackish-fuscous discal spot; at end of cell a similar spot preceded by whitish scales; cilia grayish fuscous and buff mixed. Hindwing buff basally shading to grayish fuscous distally; cilia buff with slight mixture of grayish fuscous. Foreleg buff heavily overlaid fuscous; midleg similar but with well-defined fuscous bar on outer side of tibia; hindleg buff strongly overlaid and suffused fuscous. Abdomen olive buff dorsoanteriorly, fuscous dorsoposteriorly; ventrally with buff scaling.

Male genitalia slides USNM 25128. 25129. Harpe costa terminating in a short, sharp point; sacculus produced as a dull-pointed process; cucullus long, slender, spatulate. Uncus bulbous basally; distally pointed. Vinculum U-shaped; saccus short, weak. Tegumen more than twice as long as broad. Anellus a small, oval plate with lateral sclerotized extensions. Aedeagus with slender, sclerotized rod dorsally.

Female genitalia slide USNM 25051. Ostium small, oval in a deep V-shaped cleft

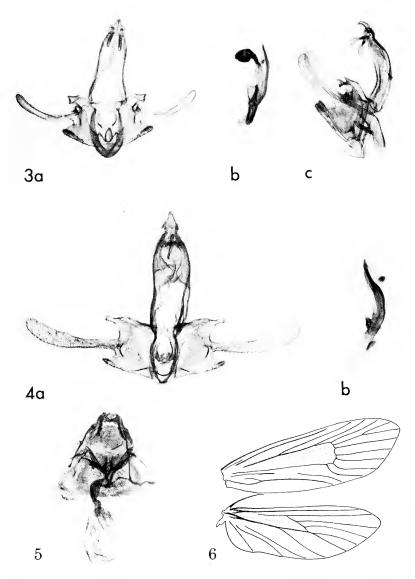


Fig. 3. Odonna passiflorae, n. sp. a, ventral view of male genitalia with aedeagus removed; b, aedeagus; c, lateral aspect of male genitalia with aedeagus in situ.

Fig. 4. Odonna xenodora, n. sp. a, ventral view of male genitalia with aedeagus removed; b, aedeagus.

removed; b, aedeagus.
Fig. 5. Odonna passiflorae, n. sp. a, ventral view of female genitalia (papillae anales missing).

Fig. 6. Odonna xenodora, n. sp. wing venation.

in 7th sternum; lamella postvaginalis granular. Inception of ductus seminalis slightly anterior to ostium. Ductus bursae membranous. Bursa copulatrix membranus.

Holotype. USNM 100175.

Type locality. Colombia, Valle, Tenerife.

Distribution. Colombia.

Foodplant. Passiflora mollissima Bailey.

Described from the  $\Omega$  holotype (May 1980) and 2 of paratypes as follows: Colombia, Valle, Tenerife, June 1981; Colombia, Valle, July 1981. No collector is indicated on the labels, but the specimens were submitted to me by Patricia Chacon de Ulloa and Marta Rojas de Hernandez who may be the collectors.

Although generically distinct, passiflorae is similar in appearance to the North American Apachea barberella (Busck), but is lighter in color and lacks the brush of the second segment of the labial palpus.

## Odonna xenodora Clarke new species. Figures 2, 4, 6

Alar expanse 38 mm.

Labial palpus missing. Antenna pinkish buff with very faint darker annulations. Head pinkish buff with fuscous scales posteriorly. Thorax pinkish buff with sparse fuscous irroration. Forewing ground color buff with fuscous irroration; in cell a conspicuous longitudinal streak; at end of cell a white discal spot surrounded by fuscous scales; veins streaked with fuscous; around tornus and along termen fuscous streaks; cilia mixed buff and fuscous. Hindwing very pale gray (or sordid white) with veins indicated by pale grayish fuscous; cilia mixed grayish fuscous and buff. Foreleg and midleg buff overlaid fuscous; hindleg buff with sparse fuscous irroration. Abdomen first three segments golden dorsally, third segment irrorate with slender fuscous scales posteriorly; remainder sordid white dorsally slightly suffused and faintly irrorate grayish fuscous; ventrally sordid white irrorate with fuscous; abdominal terga not setose.

Male genitalia slide USNM 25135. Harpe costa short, terminating in a digitate process preceded by two small cones; sacculus with distal extention; cucullus long, straplike. Socius pendant; fingerlike. Uncus broad basally with a basal point on each side; apex pointed, hooked. Vinculum narrow; saccus slender. Tegumen two-and-ahalf times as long as wide. Anellus with basal plate and lateral sclerotized extensions. Aedeagus pointed, with strongly sclerotized rod on one side.

Holotype. USNM 100176.

Type locality. Colombia, Cauca, Paramo de Purace, Lake San Rafael, 3570 m. Distribution. Colombia.

Foodplant. Unknown.

Described from the unique of holotype (29 Jan. 1959, J.F.G. Clarke).

Similar to passiflorae, new species, but larger and easily distinguished by genitalia.

This species exhibits the phenomenon of the increase in wing area, in proportion to body weight, induced by altitude, commonly found in Andean species.

Acknowledgments. The photographs were taken by Mr. Victor Krantz, Smithsonian Institution. The drawing of wing venation was done by Mrs. Elsie Froeschner.

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### Notes

A Recondite Breeding Site for the Monarch (Danaus plexippus, Danaidae) in the Montane Sierra Nevada

The Monarch butterfly (Danaus plexippus L.) traverses enormous distances in its annual migrations. These movements must carry it through or over extensive areas of habitat unfavorable for breeding, such as continuous forest and high-altitude montane regions, but data concerning its behavior in crossing such potential barriers are scanty. The Monarch as a breeder is characteristically associated with disturbed habitats in which species of milkweeds (Asclepiadaceae) behave as ruderals or range weeds, and little has been documented on its ability to find native milkweeds in their natural habitats, especially in mountainous regions. It seems certain that disturbance by man and overgrazing by his livestock have made host-finding easier for female Monarchs; in the pristine state stands of the hosts must have been much more scattered in the west, at least.

The Asclepiadaceae do not usually reach high elevations in California. Asclepias speciosa Torrey reaches 3030 m in the Convict Creek Basin on the east slope of the Sierra Nevada, but records above 2000 m are generally rare. The Monarch crosses the mountains in its seasonal migrations (it is observed as a migrant in Donner Pass in both spring and fall but does not have any host plants there, at 2100 m). Shapiro, Palm, and Wcislo (1981, J. Res. Lepid. 18(2): 92) found it breeding on A. cordifolia (Benth.) Jeps. above 2000 m on Packer's Peak; this is a very isolated stand of less than a dozen shoots, and required a traverse of at least 1.5 km of continuous forest from the nearest road. A much more isolated stand colonized by Monarchs was found on 18 July 1981 in the northern Sierra Nevada by Mr. William Overton and the author. This stand covers more than 1 ha on both sides of USFS road 19N14, about 1.5 km NNE of English Mountain Ranch, Sierra County, near Damfine Spring (ca. 1940 m). Asclepias speciosa is the most conspicuous plant, and on the date of our visit was in full bloom. About 30 adult and 50 larval Monarchs were observed. The site is located in R13E, T18N, mapped on the USFS "Foresthill and-Big Bend Districts, Tahoe National Forest" sheet (1966) and in the NE corner of the USGS Emigrant Gap topographic 15' quadrangle. It is accessible from the south by USFS road 18N18 from Highway 20 and from the north (Henness Pass) by road 19N03.

This breeding site is surrounded by dense, continuous coniferous forest, completely free of Asclepiadaceae, for at least 9 km in all directions, except for a

small and equally isolated boggy meadow at English Mountain Ranch (no milkweeds). The nearest known Asclepiads are about six plants of A. cordifolia at 1700 m near the Bear River on USFS 18N18, an airline distance of 17.5 km from Damfine Spring. There are few flowers and almost no butterflies along these roads, except at English Mountain Meadow, where no Monarchs were seen. In fact, no Monarchs were seen from the junction of 18N18 with Highway 20, via 19N14 and 19N03 to Henness Pass Road to Highway 89, a 65 km trip, except at Damfine Spring. The only other butterflies seen at Damfine Spring were male Speyeria zerene ssp., despite the superabundant nectar resources.

There is no question of the Monarch's ability to traverse the distances from its more usual agricultural-ruderal breeding sites to Damfine Spring, but what is striking is that it was able to find and colonize so remote an island of milkweed in a sea of conifers. One may be forgiven for speculating that the probability of such sites being found by parasites of the Monarch is much lower than more conventional ones, and that they may contribute disproportionately to seasonal reproduction. We will watch this site in future years to determine whether it is routinely used and whether parasitism is high or low compared to more open, weedy sites.

Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

Mate-Locating Behavior of Gnophaela latipennis vermiculata G. & R. (Pericopidae)

Gnophaela latipennis vermiculata is one of the most conspicuous day-flying moths in the Rocky Mountains. It is figured by W. J. Holland (1903 reprinted 1968. The Moth Book. Dover Publ., N.Y.). Adults are typically found in moist valley bottoms in the Canadian Zone. The strangest feature of the moths is that nearly half of the adults seen are copulating, on yellow (sometimes white) flowered Compositae growing in meadows or near streams. In their frequency of copulation they rival only the bluish Epicauta beetles (Meloidae), popularly termed love bugs, that mate and feed on various legumes in Colorado. The moths are nearly absent in the morning, and start to patrol the valley bottoms starting about 1300 (24-hour standard time), and patrol conspicuously the rest of the afternoon. I found many copulating pairs at 1310, 1350, 1400, 1420 and 1830, usually resting on the composite flowers. Adults sip nectar from the composites also. Adults are probably distasteful to most predators, because they fly slowly and are very conspicuous, I have collected ssp. vermiculata at Taos Ski Basin, 10400', Taos County, New Mexico, August 22-23, 1979; Toll Ranch, Gilpin County, Colorado, July 28, 1977; 3 miles NW Nederland, Boulder County, Colorado, July 24, 1977; Jim Creek, Grand County, Colorado, August 9, 1977; Diamond Peak, Moffat County, Colorado, July 8, 1972; Willow Springs Guard Station, Sublette County, Wyoming, August 8, 1980; and ssp. latipennis Bdv. at Cedar Pass, Modoc County, California, August 4, 1974; and 2 miles W. Old Mill Campground, Colusa County, California, June 8, 1974 (mating was not observed in ssp. latipennis).

James A. Scott, 60 Estes Street, Lakewood, Colorado 80226

On Colias hecla Lefebvre re a recent paper by Oosting & Parshall (Lepidoptera: Pieridae)

In a recent paper on the butterflies found in the region of Churchill, Manitoba (Oosting & Parshall, 1978(80), Ecological notes on the butterflies of the Churchill region of northern Manitoba, J. Res. Lepid. 17(3): 188-203), the authors misquoted a statement that I made about the behavior of *Colias hecla* Lefebvre in an earlier paper (Ferris, 1974, Notes on arctic and subarctic collecting, J. Res. Lepid. 13(4): 249-264). I would like to correct this situation, and offer some additional comments about the behavior of this butterfly.

With reference to the paper cited above, Oosting and Parshall have stated: "The authors have found no records of this butterfly from the taiga zone. Ferris (1974, p. 257) misquotes Masters (1971, p. 8) when reporting the occurrence of hecla below treeline." The statement that I made concerning the habitat of hecla was based upon my own collecting experience at Churchill in 1973. Specifically, I stated: "When they first appear on the wing, Colias nastes and hecla can be found a mile or more into the Taiga, along the railroad right-of-way (cf. Masters, 1971, p. 8)." Apparently Oosting and Parshall misinterpreted the abbreviation cf., meaning compare. In this case, compare with Masters (1971) who stated: "Colias hecla is quite rare at Churchill, but is apparently a breeding resident there. As far as I know (I have not personally taken the species) all of the examples taken have been taken over climax high tundra." (Masters, 1971, The butterflies of Churchill, Manitoba, The Mid-con. Lepid. Ser. 2(25): 1-13.)

In 1973 at Churchill, I collected *C. nastes moina* Strecker first in the taiga well south of Dene village, and later, as the season progressed, in the climax tundra. My only captures of *C. hecla hela* Strecker were in the taiga in open clearings. I departed Churchill in mid-July, apparently before *hecla* appeared over the climax tundra. In addition to apparent habitat preferences, there are phenotypic differences in *C. hecla* at Churchill which I have reported in another paper that discusses the taxonomy of *C. hecla* (Ferris, 1981, Revision of North American *Colias hecla* Lefebvre (Pieridae: Coliadinae), Bull. Allyn Mus. Entomol. *In press.*)

I have also collected *C. hecla* in British Columbia and Alaska, and have accurate records from the Yukon Territory and other arctic regions. In British Columbia, *hecla* can be taken in open clearings in forested areas (taiga) along the Alaska Highway. It shows a definite preference for the World War II emergency airstrips, now overgrown with low vegetation. It occurs in similar areas in the vicinity of Kluane Lake and Haines Junction, Yukon Territory.

My experience with *C. hecla* in Alaska has been at Murphy Dome (NW of Fairbanks), McKinley Park, and Eagle Summit (ca. 110 miles (68 km) N. of Fairbanks on the Steese Highway). Murphy Dome is above treeline and the "alba" female form of *hecla* may be taken there. The only *hecla* that I observed in McKinley Park were flying over tundra (above treeline). At Eagle Summit, *hecla* was collected in the forested area below and to the north of the Summit proper. Above-and-below treeline habitats are common in Alaska for several butterfly species, including: *Oeneis jutta* ssp., *Clossiana chariclea* ssp., *Clossiana polaris* ssp. and *Clossiana freija* ssp.

From my experience with many species of arctic and arctic-alpine butterflies, flight patterns sometimes vary annually with certain species. This perhaps accounts for the reason that I found C. hecla in the taiga at Churchill, while Oosting and

Parshall did not.

Clifford D. Ferris, P. O. Box 3351, University Station, Laramie, WY 82071

Further migrations of Hipparchia semele (L.) in 1976 and 1980

A substantial migration of the Grayling, *Hipparchia semele* (L.) was reported in France in the autumn of 1975 (J. Res. Lepid. 15(2): 83-91, 1976). Since then two other migrations of H. semele have been seen, one in the autumn of 1976 and the second in 1980. There were no movements of butterflies during the other years.

No quantitative results are available for the migration of 1976 which happened in early September in the same place, that is at the French address above. The migration of 1980 occurred a little earlier in the same locality and was seen to be in motion a few days before the following results were collected by one of us (P.D.) on the 29th of August. The following day an outbreak of stormy weather prevailed and persisted until the 7th of September when there was a feeble resumption of the migratory stream.

Table I Number of Butterflies Passing a Transect

Time	Number of Butterflies Seen Every 5 Minutes	Total	
1000 - 1100	7, 12, 14, (-), 8, 19, 17, 22, 23, 20, 24, (-)	166	
1100 - 1200	21, 22, 25, 19, 15, 24, 27, 26, 29, 19, (-), (-)	227	
1230 - 1330	20, 22, 19, 24, 27, 24, 23, 26, 24, 27, 20, (-)	256	
1330 - 1430	22, 19, 20, 18, 16, 20, 15, 13, 10, 12, 7, 5	177	
1430 - 1530	9, 6, 5, 8, 10, 4, 6, 3, 2, 0, 1, (-)	54	
<b>Grand Total</b>		880	
(Methods as descr	ibed in 1976 paper, (-) = not recorded)		

The results show that there was a peak of flight activity between 1100 - 1300 with a maximum of 29 butterflies recorded during one five minute period. In 1975 no such clear maximum was apparent.

The numbers of butterflies on migration in 1975 and 1980 were equally impressive, 596 seen during four hours in 1975 and 880 seen in five hours in 1980.

It is interesting to note that H. semele was migrating with dragonflies which apparently move in this southeast direction every year at the end of August.

In conclusion we would like to say that the migration of *H. semele* appears to be a fairly regular occurrence in this region and has been recorded in three out of six years.

John Feltwell, Marlham, Henley Down, Catsfield, East Sussex, TN33 9BN, ENGLAND and Patrick Ducros, Cabanevielle, St. Martial, Sumene, 30440, FRANCE

An Interfamilial Courtship (Lycaenidae, Pieridae)

On 6 April 1982 a fresh male Glaucopsyche lygdamus cf. incognitus Tilden was observed pursuing an unidentified larger butterfly near Davis, Yolo County, California. The larger butterfly was unidentifiable in flight: it appeared silverygray with a bluish cast and was reminiscent of the Argentine "silver Satyrid," Argyrophorus argenteus (Blanch.). The pursuit, which was first noted at 1255 hours, continued for about three minutes on a steep highway embankment. During this time the unidentified butterfly lit momentarily twice. I was able to overtake the pair as it lit a third time and determined it to be a white female Colias eurytheme Bdv., of the vernal phenotype, exceptionally small and very heavily infuscated beneath. The male lygdamus lit on the forewing of the Colias as it positioned itself for thermoregulatory lateral basking (the ambient temperature was only about 13°C) and then attempted repeatedly to make genital contact from a position centered roughly over the hindwing discocellular spot. The pair was collected at 1303 after the female rose to take flight. Her left forewing measured only 20 mm from base to apex, quite small for a Colias but considerably larger than the male's 14 mm. She is among the most melanic vernal examples in our very long series at Davis.

Females of the Davis population of *lygdamus* are partially blue dorsally and lustrous pale gray-brown ventrally. The distinctly silvery-gray-bluish cast of the female *Colias* in sunlight, which was baffling to me, very probably fooled the male *lygdamus* as well. Fresh female *lygdamus* and mating pairs were observed in the immediate vicinity.

Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

Celastrina ladon (Lycaenidae) Females Ovipositing on Sambucus canadenis, a Plant Unsuitable for Larval Development

From 8 to 16 June 1981 I repeatedly observed female Celastrina ladon (Cramer) oviposit on the flower buds of Sambucus canadensis L. (Caprifoliaceae) in Upper Tyrone Township, Fayette Co., Pennsylvania. A close examination of the six flowering bushes in the general area revealed that each flower head contained from one to two up to several dozen eggs. Wild eggs taken from the flower heads and ones laid on flower buds by captive females hatched normally in the laboratory, and the larvae began to feed. Within two days, however, all larvae left on Sambucus had died. About 50 larvae were transferred to Melilotus officinalis (L.) Lam. (Leguminosae), the dominant foodplant of second generation C. ladon in this area, after feeding on Sambucus for only a few hours. All but two or three of these larvae died during the next day. A further examination of Sambucus in the area of oviposition observations and in Preston Co., West Virginia, revealed many additional unhatched eggs and shells of hatched eggs, but no sign of larvae. All parts of this plant contain hydrocyanic acid (G. A. Petrides, 1958, A Field Guide to Trees and Shrubs, Houghton Mifflin, Boston, p. 32), and the flower buds are apparently toxic to young C. ladon larvae. In light of this, it is surprising that females should oviposit so readily on this plant in nature.

Charles G. Oliver, R. D. 1, Box 78, Scottdale, Pennsylvania 15683

### **Book Reviews**

The Audubon Society Field Guide to North American Butterflies. Robert Michael Pyle. 1981. 916 pages, 759 colored figures. Alfred A. Knopf, New York. Price: \$11.95, paperback.

The best feature of this book is the superb color photos of butterflies in natural settings. Generally these show true colors and picture all North American species. However, a few figures depict rubbed, out-of-focus, or even "nature faked" specimens. One exasperating aspect is that only common names (some newly-invented) are given for the figure captions and text discussions. The photos alone are not always adequate to identify certain species of Speyeria, Euphydryas, Euphylotes, Thorybes, Erynnis, Hesperia, Agathymus and other taxonomic problemgenera.

The introduction stresses watching, photographing, and rearing butterflies and cautions against over-collecting. The text emphasizes description, similar species, life cycle, flight times, habits, habitats, and range. Entirely too much space is devoted to the descriptions and similar species. Because of the identification format, the organization is unorthodox. There is little mention of subspeciation which is rampant in the West. Hostplant data is accurate but skimpy. The style is variable, often captivating and drawing on a wealth of information, but sometimes verbose and redundant. It is not clear how much of the information is from Pyle's personal experience, the literature, or from others, as facts are not backed up by referencing. The habits, habitat, and conservation discussions are positive features. Special attention is given to migrant species and weedy species of disturbed habitats. The new Brown & Miller check list is followed rather disconcertingly in its generic splitting, and the commoner species' synonyms are mentioned. In the back there is a glossary of terms, picture credits, host plant index, and butterfly name index (common and scientific names combined).

Some important biogeographic information is scattered in the text. For example, Neohasia is related to the South American Catasticta, and Neominois, Habrodais, and Hypaurotis are related to East Asian species. Strymon avalona and Boloria acrocnema have the most restricted ranges of any Nearctic species, and Plebejus neurona, Lycaena hermes, and Strymon avalona are peculiarly endemic to southern California. Vanessa tameamea (Hawaii) is probably derived from the Asian V. indica, and another Hawaiian endemic, Vaga blackburnii, is related to a Bonin Islands species.

Ranges are generally accurate, but Euptoieta claudia and Eurema mexicana are not residents of Southern California, Libytheana bachmanii is not mentioned for Arizona and Southern California, and Speyeria callippe is not mentioned for Southern California. Under Speyeria edwardsii, "Of the western fritillaries, this is the only one which varies constantly throughout its range," is a misstatement. Oakley Shields, 4890 Old Highway, Mariposa, CA 95338.

The color photos in this book are superb, and make the book worth the price. The photos are mostly of living butterflies in natural surroundings. The text is suitable

for the novice butterfly enthusiast, and has the virtue of giving a description, life cycle, flight, habitat, and range for most species.

The book also has shortcomings and numerous errors. Identification is made more difficult by four drawbacks: a) at least 27 photos are misidentified (correct names are: 326 & 337 P. polyxenes, 89 C. interior, 108 P. agarithe, 127 K. lyside, 516 L. helloides, 457 I. niphon, 430 C. apama homoperplexa, 509 C. argiolus, 543 C. nemesis, 553 E. ares female, 365 L. bachmannii larvata, 607 left S. coronis halcyone, 613 left C. bellona, 590 P. campestris female, 368 left P. zephyrus, 368 right N. vaualbum, 654 A. iphicla, 759 H. guatemalena, 758 H. februa, 686 S. blomfildia, 663 right A. leilia, 662 right A. celtis, 732 O. taygete, 735 O. jutta?, 285 T. confusis female, 165 O. sylvanoides—the black pages make correcting these errors difficult—one must use "Liquid Paper" to whiten a space for inking); b) many photos are of butterflies in postures that make them unidentifiable (upperside instead of underside, or vice versa, or a view showing only the body such as photos 205-210, the diagnostic spot of A. belli is hidden by the HW on photo 199, etc.) so individuals of these species cannot be identified; c) many species have no photo, and are illustrated by line drawings in the text, which are generally small, rather faded, and poorly drawn; d) many species have no photo or drawing, and are mentioned only in 1-2 lines appended to another species. Photos 116, 323, 380, 381 and 475 seem to represent dead butterflies. It will evidently take many more years to accumulate good photos of all the North American butterflies in a living state. The photos are sorted into 14 groups based on rough appearance (the white butterflies are mostly grouped together for instance, although the white forms of Colias are shown with the yellow butterflies). The grouping of many species is debatable, although the amateur may find this feature of the book useful. There are only three photos per page, so considerable flipping through the small book is necessary to find the right photo. These deficiencies in the photos mean that only the visually distinct species will be able to be identified using the book, and species that are similar to others cannot be identified to species.

The photos give only the common names, many of which are new, so to determine the identity of them one must turn to the text. Most traditional common names are retained, although many are new, and some new ones are unfortunate (for instance the "Sheep Skipper", A. ovinia, is named for the Navajo Indians' sheep, but actually A. ovinia inhabits extreme southern Arizona; the Navajos inhabit northern Arizona).

Another limitation is the coverage of the book. Five hundred seventeen species are illustrated in color (excluding those misidentified), 61 in line drawings, and the remaining about 122 of the 700 North American species are not illustrated at all. Only about 600 of the 700 species have full treatment in the text. Two widespread native species, Euphilotes spaldingi and Cogia outis, and about 30 strays to the United States from Mexico or the Antilles, are not mentioned at all. Pseudolycaena marsyas does not occur in the United States.

The text is adequate, although numerous errors detract from its value. The generic names used in the book are highly split, many familiar names such as Papilio glaucus and Pieris rapae falling by the wayside. Some species names are doubtful (Calephelis "guadeloupe" a synonym of nemesis, Euphyes "ruricola" a nomen dubium, Celastrina ebenia a synonym of C. nigra, Agriades "franklini" is A. glandon, L. astyanax a ssp. of L. arthemis, etc.).

Many larval foodplants are errors. Some plants are lab hosts only, and are doubtfully used in the field (Heracleum for Papilio joanae, Trifolium for Phoebis sennae, Eurema lisa and Zerene eurydice, Muhlenbergia for Lethe anthedon, Althaea for Celotes nessus, Stenotaphrum for Nastra julia, Prosopis juliflora for A. palmeri, Poa, Avena and Cynodon all for Amblyscirtes vialis). Thlaspi is refused by Pieris napi larvae. Horkelia and Potentilla are doubtful for Lycaena xanthoides editha. Polygonum douglasii applies to Lycaena nivalis, not L. mariposa. The S. macfarlandi host is Nolina texana, not microcarpa. Ceanothus macrocarpus is now megacarpus for S. saepium. Myrica is refused by Calycopis cecrops females and larvae. Trema floridana is now micrantha for S. martialis. Salicornia ambigua is a synonym of virginica for B. exilis. Hosackia purshiana is dubious for Plebejus emigdionis. Castilleja is an error for C. palla. Ulmus is an error for P. zephyrus, Rhododendron an error for P. oreas. Sorghastrum nutans is dubious for N. areolata. Asclepias is unverified for Danaus eresimus. The E. zestos host is a herb, not woody. Canna is an error for O. proteus. The A. anaphus host is "wild bean," not Phaseolus. Malva, Abutilon and Althaea plants are based on H. Tietz' "syrichtus" and apply to P. communis, not P. oileus. Malva is an error for P. catullus. The host of Euphyes dion, Scirpus, is a bulrush (Cyperaceae), not a rush (Juncaceae). Sorghastrum nutans and secundum for Amblyscirtes hegon are somewhat doubtful, based on Abbot. Agathymus neumoegeni larvae do not feed in roots as stated. Certain plants are misspelled throughout: Dryapetes, Saccharum, Gaultheria humifusa, Porlieria, Rumex triangulivalvis ("triangularis"), Quercus gambellii, Cuscuta, Rivina, Lippia graveolens, Prunus havardii, Stenandrium.

Few hibernation stage records are given, and nearly half of those given are wrong. The correct stages are: Colias philodice and eurytheme 3-4 stage larvae, Lycaena phlaeas and cupreus half grown larvae, Lycaeides melissa half grown larva, S. hydaspe newly hatched larva, Erynnis baptisiae probably mature larva, Hesperia comma egg, H. metea mature larva, Polites mystic 4th stage larva (see J. Res. Lepid. 18: 171-200).

The larva and pupa descriptions are mostly adequate, although brief. The *Panoquina panoquinoides* larva and pupa descriptions refer to *P. errans*. The descriptions of larvae and pupae of *Erynnis* are poor and are repeated almost verbatim for most of the *Erynnis* species, including several species that have never been reared.

The ranges are mostly correct although often underestimated. However, some regions stated are errors: P. pilumnus, Z. eurydice, C. definita, C. perditalis and C. mossii do not occur in Arizona, H. charitonius is not a resident in South Carolina, P. orseis is not in NE Nevada, T. leanira is not in E. Colorado or New Mexico, Z. cyna is not in New Mexico, E. favonius is not in West Virginia or Louisiana, C. sheridani is not in Saskatchewan, C. hesseli is not in Mississippi, H. grunus is not in Idaho or "coastal Arizona", L. xanthoides is not in the Great Basin, L. phlaeas is not in Florida, C. occidentalis is not in Alaska, A. pima and P. rudkini are not in SE Utah, P. beckeri is not in Black Hills, P. hylas is not in W. Nebraska, the P. zephyrus record from Manitoba was a misdetermination. P. progne, P. oreas is not in NE Wyoming, C. henshawi is not in W. Texas, N. areolatus is not in Kentucky, P. araxes is not in S. Texas, P. manueli is not now in Florida, P. mercurius records from Arizona-New Mexico are errors, U. teleus and A. toxeus and G. gesta records from Arizona are errors, E. persius is not in Maritimes, P. alpheus is not in Oregon, N. julia is not in

Alabama, H. dacotae is not in Illinois, H. sassacus is not in Tennessee, H. attalus is not in Nebraska or Wisconsin, P. origines is not in Montana, P. zabulon is not in Wisconsin, P. taxiles is not in Nevada, P. viator is not in Maine, P. hobomok is not in the Sangre de Cristo Mts., A. aesculapius is not in Connecticut or New Mexico, M. cofaqui is not in N. Texas.

Some sedentary species are wrongly listed as strays (C. goodsoni, P. errans, Agathymus ("Brown Bullet") estelleae, Pholisora mejicana), and Heliconius erato is treated as a native with no mention that it is actually a very rare stray.

The flight periods listed are mostly correct (although N. terlooti flies in June-July also, Colias alexandra has two broods on the plains, Boloria eunomia has a several week flight period (not 4-5 days as stated), etc.). The number of broods for multivoltine southern species are underestimated throughout the book (Eurytides marcellus has 3-4 broods from April-October, not two, for instance); in many cases when only two broods are listed the number of generations per year is probably four or more.

The introductory material gives very elementary information for the beginner on anatomy and the life cycle, etc. Concepts such as photoperiod do not appear in the book. Flowers visited by adults, and adult migrations, are listed. There is nothing on mate-locating behavior in the book, although anecdotal reference to territoriality are given throughout the book, although the application of this concept to butterflies is disputed by research workers. Pheromones are attributed to T. elada, S. hydaspe and L. creola, when really they have never been studied. The white female form of Ascia monuste also migrates. Colias behrii is a subalpine, not an alpine, species, and the definition of alpine in the glossary ("pertaining to or inhabiting mountains") is peculiar.

Overall, the photos are excellent, and the text is suitable for the beginner, but the numerous errors mean that the book must be used with caution by lepidopterists.

James A. Scott, 60 Estes Street, Lakewood, Colorado 80226

Butterflies of the Rocky Mountain States

Ferris, C. & F. M. Brown, eds., with 8 contributors (F. M. Brown, D. Eff, S. L. Ellis, C. D. Ferris, M. S. Fisher, L. D. Miller, J. A. Scott and R. E. Stanford). 1981. 442 p. Univ. Oklahoma Press.

This book should serve a useful purpose in allowing the identification of Rocky Mountain (exclusive of Canada and Alaska) butterflies and skippers, and presenting their distributions, and a little about their foodplants and habits. Overall, it is a good book, especially for distribution and identification. It does contain some errors, however. I have studied Rocky Mountain butterflies for 23 years, and hope these comments will be useful to Lepidopterists who use the book as a factual source.

The maps are the best feature of the book, and represent a considerable amount of effort by Stanford (and the reviewer); the one drawback of the maps is that the dots are placed in the middle of each county rather than at the exact collection site, which makes the ranges in mountainous and other non-uniform areas appear too large in many cases. The county lines usually run along the top of mountain ranges, so two

specimens from the top of a peak may be widely separated on the maps. The boundaries of the area covered as shown on the maps are not rigidly adhered to in the text: Poladryas minuta minuta from northeastern New Mexico is missing from the book (more on it later), as is Euchloe creusa which will probably be found in Glacier National Park, while Atrytonopsis deva, Thymelicus lineola, Ancyloxypha arene, Precis evarete nigrosuffusa, and Ascia josephina (a possible stray) do not occur near the region but are fully treated in the book, and the following are given full treatment even though they are almost certainly mislabeled from the region: Thorybes diversus, Poanes zabulon, Pompeius verna, Wallengrenia egeremet, Piruna polingii, Emesia zela, Parrhasius m-album, Cyllopsis henshawi. It should be noted that timberline is about 7500' on the Montana-U.S. border, not 9000' on p. 15 or 11000' on p. 289.

The photos are black and white (except for several color plates), but are well done for the most part, although some are a bit faded (especially *Oeneis jutta*), the first photo of *Oeneis chryxus* is actually *O. uhleri*, the photos of *Cercyonis pegala damei* are *C. p. boopis*, the first photos of *Pieris sisymbrii* and *Cyllopsis henshawi* are females not males, the scale of the "Pyrisitia" proterpia and Nathalis photos is not 1X, and the *Everes comyntas* photos are of specimens that unfortunately resemble *E. amyntula*.

The authors are not properly credited in the text in many cases; one must consult the Table of Contents to find who authored what.

Butterflies are made to appear ferocious in the book. "Attacks", "mock combat", "pugnacity", "combative" and "territories" on pp. 60, 226, 228, 232, 346 and 348 are actually misinterpretations of male mate-locating behavior (see Amer. Midl. Nat. 91: 103). Actually, butterfly adults have no offensive weapons with which to fight, and it is the *larvae* which are often territorial (see J. New York Ent. Soc. 81: 214 and Oecologia 52: 415 for descriptions of larval battles) or even cannibalistic.

Considerable space in the book is devoted to purely taxonomic matters (type localities and dates of publication, type species of genera, etc. are given), which is surprising in a regional work. Numerous taxonomic changes are made, and comparing the scientific names with such books as Klots (1951) Field Guide, Ehrlich & Ehrlich's (1961) How to Know the Butterflies, and Howe's (1975) Butterflies of North America, the book is an orgy of splitting. The cabbage butterfly is no longer Pieris, the Tiger Swallowtail no longer is Papilio, etc., etc. A. Klots (Bull. Brooklyn Ent. Soc. 31: 154) and T. N. Freeman (Can. Ent. 68: 277) both published generic revisions of Lycaena, but their work is scrapped and numerous genera used which differ very slightly (L. rubidus and L. xanthoides in particular have very similar genitalia contrary to p. 229, and hybrids between them are known, see J. Res. Lepid. 8: 51 & 18: 50). Apparently the authors used the genera found in the new "A Catalogue/Checklist of the Butterflies of America North of Mexico" by L. Miller & F. Brown (Lepid. Soc. Memoir no. 2). That work, however, abolishes subgenera completely (not a single one is used), which is contrary to the opinions of most zoologists and is certainly not warranted by any rule of nomenclature or logic; therefore, these generic changes should be ignored by all zoologists except those few who share a disdain of subgenera. Some names in the book do differ from the Miller/Brown catalogue: the Catalogue uses Polites coras for peckius\*, Euphyes ruricola for vestris\*, Agriades franklini for rustica (glandon\*), Atrytonopsis cestus margarita for python margarita\*, Euphilotes pallescens for rita pallescens\*, Celastrina

ladon for argiolus (argiolus ladon\*), Incisalia fotis mossii for mossii\*, Coenonympha ochracea, ampelos and inornata as three separate species instead of ssp. of C. tullia\*, and Erebia epipsodea rhodia\* for epipsodea (the asterisks show the names that are probably correct). The studies of higher classification by P. Ehrlich, almost the only person this century who has scraped off the body scales to see what is beneath (Univ. Kansas Sci. Bull. 39: 305-370) are ignored, and doubtful categories such as Anthocharinae and Marpesiinae are used. Anthocharis and Euchloe actually belong in the Pierinae close to Pieris; all have the same foodplants and body enzymes (see J. Res. Lepid. 19: 181).

The following are detailed comments, arranged in taxonomic sequence, proceeding through the book from start to finish. Hesperiidae. The white fringed ssp. of Thorybes pylades does not occur in Idaho as stated on p. 71. Erynnis propertius and meridianus have the same genitalia, as do E. zarucco and funeralis, and appear to be conspecific (and see p. 79). The foodplant Potentilla anserina for Pyrgus xanthus is a misidentification of P. hippiana. Amblyscirtes simius does not perch late in the day. only in early morning (see J. Anim. Ecol. 42: 663); the observations reported were made after a dark thunderstorm, and are highly exceptional, if indeed they represent mate-locating behavior. Amblyscirtes aenus has been reared from eggs laid by A. "erna" (J. Res. Lepid. 15: 92), so erna is a form of aenus, not a species as implied on p. 94. Amblyscirtes fimbriata has orange fringes. The type locality of Atrytone logan lagus is Oak Creek, Fremont (not Custer Co., CO, which is probably an error anyway because the species does not occur in either county now. Ochlodes sylvanoides napa is a weak ssp. only in the Colorado Front Range, distinguished only by larger size (see Papilio (New Series) no. 1, available from the reviewer). Polites sabuleti is not alpine as stated in the figure caption on p. 118. P. draco and sabuleti actually have identical genitalia and no structural differences (contrary to p. 119), and apparent intermediates occur on Grand Mesa, Colorado. The Festuca idahoensis foodplant of Polites sonora is only a guess by E. J. Newcomer (J. Res. Lepid. 5: 243) (actually some moist meadow grass is more probable), and Distichlis is only a guess for Atalopedes campestris (by L. Orsak, Butterflies of Orange County, Univ. Calif. Press). Hesperia comma colorado is actually annual in appearance, and has adapted to the subalpine zone with a shorter developmental period (J. Lepid. Soc. 29: 156). It is not biennial as stated on p. 125. Ssp. assiniboia has an ochre VHW. Hesperia woodgatei males actually perch on hilltops (J. Res. Lep. 14: 1) and not in gullies as stated on p. 128. Hesperia nevada males usually perch on hilltops also, H. pahaska flies 1½ months (not 3) earlier than H. leonardus montana. The foodplant Digitaria of Copaeodes aurantiaca is an error by H. Tietz (An Index to the Described Life Histories, Hosts...; Allyn Museum). Megathymus coloradensis is treated as a species even though the latest revision by K. Roever in 1975 treated it as a ssp. of M. yuccae (p. 144 correctly notes the limited utility of chromosome counts). M. streckeri texanus is characterized by the large DHW postmedian spots in females, rather than the characters given.

Pieridae. Neophasia menapia tau is a synonym of menapia (the California coast ssp. was recently named ssp. melanica, Papilio no. 1). Pieris napi's range decreased in eastern United States due to deforestation rather than due to competition with P. rapae as stated on p. 19 (see Amer. Nat. 118: 655). P. napi and Anthocharis sara are not semicrepuscular, they merely prefer shade. Pieris chloridice is misspelled twice on p. 150. L. Higgins' studies combining Pieris chloridice beckerii, P. callidice

occidentalis and Euchloe ausonia ausonides are ignored, and the combination Anthocharis cethura pima of T. Emmel and J. Emmel is ignored. E. ausonia coloradensis occurs only in the southern Rockies according to P. Opler's revision (J. Res. Lep. 7: 65), and ssp. ausonides occurs from central Wyoming northward. Colias meadii elis occurs in Glacier National Park, and possibly in NW Wyoming, and flies as strongly as ssp. meadii in the reviewer's experience. C. eurytheme has a spring form which is mostly yellow and is far from meaningless, being darker on VHW for better thermoregulation (see Proc. Nat. Acad. Sci. 63: 768). The appearance, habitat and behavior of C. scudderii and gigantea suggest they are conspecific, and the combination C. scudderii gigantea was proposed by John Masters. Trifolium is a lab host only for "Pyrisitia" lisa. Stellaria media (Caryophyllaceae) is probably an error for Nathalis.

Papilionidae. Parnassius phoebus actually hibernates as eggs. Ssp. pseudorotgeri occurs only in the San Juan Mountains, and not in the Sangre de Cristo Mountains. The reviewer does not know of any evidence that Parnassius clodius contains cyanide as stated. The yellow tegulae of Papilio bairdii are very useful for identification; they are much yellower than in P. polyxenes. Ssp. dodi appears to be a synonym of P. bairdii brucei. Artemisia is not a foodplant of Papilio indra. Papilio rutulus is probably a subspecies of P. glaucus, because they intergrade in southern British Columbia in male and female genitalia and wing pattern (Pan Pacific Ent. 52: 23), they intergrade in the Black Hills (Evolution 13: 40). Ssp. canadenis does not occur in the Black Hills as stated on p. 187, they merely resemble canadensis there because of the intergradation. Ssp. arcticus is an Alaskan form of P. glaucus canadensis that resembles rutulus, and not a ssp. of rutulus as stated on p. 188; rutulus does not occur north of SW British Columbia. Magnolia is not eaten by Papilio palamedes (J. Lepid. Soc. 16: 198).

Lycaenidae. Apodemia mormo ssp. mejicanus actually occurs in the region, not ssp. duryi which has a greater extent of more orange color and occurs in S. New Mexico. The report of Lycaeides idas from North America is confusing (p. 201). Actually, V. Nabokov's systematic studies (Bull. Mus. Comp. Zool. 101: 479-541) are perfectly correct; however nomenclatorial changes in Europe now mean that Nabokov's Palearctic species "ismenias" is a synonym of argyrognomon, and Nabokov's "argyrognomon" must be called idas (Forster, 1936, Mitt. Munich Ent. Ges. 26: 41-150). So all references to "argyrognomon" in North America must be changed to idas. The only two species of Lycaeides in North America are melissa and idas. Plebejus acmon lutzi does not eat Lupinus or Astragalus in the region; they are eaten in California and Arizona only. There are many reasons for using the species combination Agriades glandon rustica instead of A. rustica (J. Res. Lepid. 17: 101). O. Shields treated pallescens as a ssp. of Euphilotes rita (J. Res. Lepid. 16: 2). Alfalfa is not known to be eaten by Everes comyntas (the record referred to is actually Medicago lupulina, Black Medic). Ssp. herrii belongs to E. comyntas, not to E. amyntula. Trifolium is not eaten by E. amyntula as far as known. The Rocky Mountain ssp. of Celastrina argiolus is ladon, or possibly sidara, but definitely not cinerea, which is related to ssp. echo of California. The forms of argiolus in most of the Rockies are those that occur in ssp. ladon. Amaranthus is not a valid foodplant for Brephidium exilis. Lycaena arota males perch only in the morning, and males seldom patrol to find females (see J. Lepid. Soc. 28: 64). The arctic/alpine North American Lycaena phlaeas are very closely related to Scandinavian L. phlaeas

polaris, even to the extent of having the same form caeruleopunctata with blue spots on DHW; a relationship ignored in America. Lycaena cupreus in Montana, NW Wyoming, and Utah occurs in the Canadian Zone and represents a separate ssp. (ssp. artemisia, see Papilio no. 1). Lycaena xanthoides editha and L. x. dione are the proper combinations, not those used (see J. Res. Lepid. 18: 50). L. xanthoides is a perching species, contrary to p. 228 (see J. Lepid. Soc. 29: 63). Lycaena heteronea gravenotata is a very distinct ssp. (the book is correct in treating klotsi as a form). All references to Lycaena dorcas in the book actually refer to L. helloides, based on extensive foodplant and morphological data (see J. Res. Lepid. 17: 40). The specimens of "dorcas" illustrated are particularly similar to the helloides illustrated. Rocky Mountain foodplants of "dorcas" are Polygonum and Rumex, not Potentilla as stated on p. 233. Furthermore, Rocky Mountain "dorcas" oviposits on trash at the plant base as does helloides, whereas true eastern bog dorcas oviposits on the tops of shrubs (see Can. Ent. 41: 222). L. helloides hibernates as eggs. Polygonum douglasii is a valid foodplant of Lycaena nivalis, but an error for L. mariposa (this mixup is explained by E. Newcomer, see J. Res. Lepid. 2: 276). Harkenclenus titus mopsus does not occur in the region. Quercus foodplant of H. titus is an error by H. Tietz. Satyrium behrii has been in Satyrium since the work of Clench in 1961 (in How to Know the Butterflies), not since 1979. Cercocarpus montanus is not a valid Satyrium saepium foodplant. Eriogonum is an erroneous foodplant of Satyrium californica. Incisalia augustinus feeds on a variety of foodplants in California, but not in the east. Mitoura spinetorum has one brood only in the region (two broads occur in S. Arizona and New Mexico, see J. Res. Lep. 4: 233). The W. Colorado and SE Utah low altitude Callophrys populations actually seem to be somewhat intermediate between C. sheridanii sheridanii and C. sheridanii comstocki, the VHW line varying from straight, to kinked as in comstocki, and this line varies from a complete row of spots to nearly absent. On p. 260, 2nd line from bottom, "the region" should read "Colorado." Fixsenia is now used for the genus Euristrymon (see J. Lepid. Soc. 32: 279).

Satyrinae. Xyris torta (Xyridaceae) is an erroneous foodplant of Megisto cymela, another error by H. Tietz. M. cymela actually diapauses in the 4th instar (see J. Res. Lep. 18: 171). Cyllopsis henshawi seems to be the May-June broad of C. pyracmon, and C. nabokovi is the August-September brood; the same seasonal forms occur in C. gemma. To prove this, eggs of the first broad should be reared. Cercyonis sthenele from Salt Lake City actually resemble ssp. silvestris of California. Poa is only a lab foodplant of sthenele. C. sthenele and meadii interbreed extensively on the Kaibab Plateau just NW of the Grand Canyon, and actually ssp. damei is a ssp. of sthenele (not pegala) that has hybridized with meadii (the reviewer's 1980 research). Page 274 also mentions hybridization between the two in the Chuska Mountains (intermediate populations). These two do not appear to be completely distinct species, and may be allopatric subspecies, although the Kaibab hybridization does not appear to be completely random, perhaps because sthenele flies up from the Canyon and meadii prevails on the plateau. The dorsal stripes of Cercyonis oetus larvae are the same as those of meadii (see the detailed descriptions in W. Edwards' Butterflies of North America). Sedges are undocumented foodplants of C. pegala. Neominois ridingsi is always single brooded (the second broods reported for Oeneis uhleri, alberta and polixenes are also errors). Actually, N. ridingsi and O. polixenes are known to be biennial in some places (J. Res. Lep. 18: 171). O. alberta doubtfully

hibernates as a pupa (ibid.). O. melissa beani is characterized by its darker smoky black color, not the characters given. Arctic workers (K. Philip, C. dos Passos, pers. comm.) have found no essential difference between Oeneis bore and taygete, so bore should be the species' name.

Nymphalinae. Boloria eunomia dawsoni occurs only farther north than Wyoming, and only "ursadentis" occurs in Montana (see the map). Ssp. ursadentis and laddi are actually very similar to caelestis. The Polygonum bistorta foodplant listed for eunomia almost certainly refers to Polygonum (Bistorta) instead. The Bistorta vivipara foodplant listed for eunomia is a European host. Viola "papilionacea" foodplant of Boloria selene is a misidentification of V. nephrophylla (M. Epstein, pers. comm.), and papilionacea is not native to the region. Boloria bellona has only one brood in the Rockies. Boloria frigga saga is the ssp. in Alberta, and it probably occurs in N. Montana also. Boloria epithore borealis is a homonym of European B. thore borealis. The Dryas food of Boloria alberta is based on field association and lab oviposition only, although it is probably the field food. The new Boloria acrocnema is believed by the current revisers of Boloria (and by the reviewer, who has a mss. describing the complete life history and ecology) to be a subspecies of B. improba. The Viola tricolor (cultivated pansy) food of Speyeria idalia is only used in the lab. The neotype of Speyeria nokomis was caught by Mrs. Cockerell at Beulah, New Mexico, and sold to E. Oslar, based on correspondence from T. D. A. Cockerell to F. Benjamin of the Smithsonian. Therefore nigrocaerulea falls as a synonym of nokomis. Theoretically only the endpoints of a cline should receive names, so only the California-Nevada nokomis apacheana and the Arizona-New Mexico-southern Colorado nokomis nokomis should receive names and the intervening material should be left as clinal forms. Speyeria hydaspe conquista and Speyeria zerene were supposedly collected by A. Klots from the same two localities in new Mexico but have never been found since (M. Toliver mss. on the butterflies of New Mexico). Both are undoubtedly mislabeled specimens from Wyoming where Klots also collected. Neither species has been found south of northern Colorado. The probability that both occurred at the same two locations, then both became extinct at the same time in still-natural habitat, is infinitesimal. Speyeria zerene cynna is now treated as a synonym of S. z. gunderi (see J. Res. Lepid. 19: 242). Speyeria egleis linda also occurs in western Montana and in the Stansbury Mountains of Utah. The Viola canadensis food of Speyeria cybele is an association record only (by S. Ellis). Euptoieta claudia may actually lack a true diapause. The Siphonoglossa and Ruellia foodplants of Phyciodes texana are lab hosts only. Early stages of Phyciodes mylitta and P. pallida were published (see J. Res. Lepid. 14: 84, which gave all the differences that occur between these species and P. orseis). Phyciodes mylitta callina is an available name for the SW Colorado-New Mexico-Arizona ssp. of mylitta. The Helianthus scaberrimus foodplant of Chlosyne gorgone is a synonym of H. laetiflorus. Rudbeckia laciniata is the only Rocky Mountain host for Chlosyne nycteis, not the plants stated. Chlosyne damoetas is not strictly biennial, but rather "irregular" in life cycle length, because the half grown larvae diapause for a variable number of years, often two years but probably also 1-3 years or longer. Interestingly, the larva and pupa of damoetas are identical to those of C. gabbii. Lowland checkerspot larvae can diapause for several years (J. Res. Lepid. 18: 171), which seems to preadapt them for life in the alpine zone, so the alpine damoetas may be more closely related to lowland Chlosyne than current taxonomy suggests. Female

damoetas are variable also in Colorado; Alberta populations are somewhat intermediate to California populations. Chlosyne leanira alma occurs in west central Colorado (Mesa and Montrose Counties) and central Utah, and C. leanira fulvia occurs in SW Colorado (Archuleta, La Plata and Montezuma Counties). The two ssp. appear to intergrade in Kane County, Utah. The treatment of Poladryas is very poor. P. minuta minuta (missing from the book) occurs on the plains of Colfax County, New Mexico, where larvae have the typical red ground color. P. minuta arachne has whiter larvae and occurs only in the mountains (several thousand feet higher in altitude in Colfax County). These two subspecies have been hybridized and backcrossed in nature by releasing lab-raised females in front of wild males (the stocks from north (not west) Texas ssp. minuta and Colorado ssp. arachne) (see Pan Pacific Ent. 50: 9, 1974 not 1973), proving that there are no barriers in either courtship or development between them. This paper also mentioned series with intermediate tendencies. Ssp. minuta is not extinct as stated, being widespread in north Texas and E. New Mexico, although it is true that the most extreme phenotype is in Mexico (which is more extreme than the Kerrville Texas types of minuta). Recent studies published too late for the book place Euphydryas anicia as a subspecies of E. chalcedona (J. Res. Lepid. 17: 245). Page 331 supports this conclusion, mentioning intergrades between chalcedona and "anicia" bernadetta in N. Nevada and S. Idaho. The maps show that chalcedona wallacensis and "anicia" overlap considerably in range, but S. Kohler has found that the anicia are all at higher altitude, the chalcedona at lower altitude, and there are no known localities where they are sympatric, although they come close at St. Ignatius in Lake County. Ssp. bernadetta occurs locally in Madison County, Montana. E. editha gunnisonensis and alebarki and E. Nevada lehmani in the opinion of the reviewer are synonyms of hutchinsi. It is the adults of Nymphalis californica and not the pupae which hibernate (J. Res. Lepid. 18: 171). Salix and Helianthus are erroneous foodplants of Nymphalis milberti. Tilia is a very dubious foodplant of Polygonia interrogationis. Celtis is eaten unwillingly by Polygonia comma (see W. Edwards, Butterflies of North America), and the plants Althaea, Ambrosia and Amboris are errors of H. Tietz and are not eaten by comma. Polygonia zephyrus is a subspecies of P. gracilis (research of the reviewer); they have the same male genitalia, and are parapatric and intergrade in the Canadian Rockies. Polygonia oreas and P. oreas silenus have a second different genitalic form. Ulmus is a dubious foodplant of Polygonia progne. Ludwigia is an erroneous foodplant of Precis coenia. Nigrosuffusa is the Mexican ssp. of Precis evarete according to J. Hafernik's studies, and at any rate it does not occur in or near the region. Western Colorado records of Limenitis lorquini are errors, contrary to p. 351 (see the map). Crataegus is another H. Tietz error, rather than a valid lorquini foodplant.

 ${\it Liby the idae.} \ \ {\it All\, Liby the ana\, bachman ii} \ in \ the \ region \ are \ probably \ migrants \ of \ ssp. \\ {\it larvata.}$ 

The length of this review does not imply that this is not a good book. It is a good book and contains more information than the average butterfly book. Its presentation of distribution information is excellent. Serious Lepidopterists should note the points presented above, and in the opinion of the reviewer the generic names used in W. Howe's book (Butterflies of North America) should be used rather than the genera used in this book.

James A. Scott, 60 Estes Street, Lakewood, Colorado 80226

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# International Nepal Himalaya Expedition forLepidoptera Palaearctica (INHELP) 1977, Report No.1: Introduction and Lycaenidae

Oakley Shields1

4890 Old Highway, Mariposa, California 95338

Abstract. Seven species of steppe and alpine Lycaenidae were collected during a 1977 summer expedition which visited 13 localities in the Thakkhola region of Central Nepal Himalayas. Climatic and geologic characteristics of the Thakkhola region plus habitat profiles of the collecting localities are described. Albulina orbitulus asiatica (Elwes), A. lehana (Moore), Polyommatus stoliczkana arene Fawcett, P. nepalensis Forster, and Lycaena phlaeas baralacha Moore were residents of the Palaearctic realm, while Lampides boeticus (L.) and Rapala selira (Moore) barely enter this zone from lower elevations. L. phlaeas and P. nepalensis extend down into the Oriental realm as well. The butterfly fauna of the Tibetan frontier adjacent to Sikkim and Bhutan to the east is very similar to the Thakkhola region, while the high mountain fauna further west and northwest of Nepal is quite dissimilar except for the Kumaon Himalayan-Tibet frontier. The Oriental realm occupies the subtropical zone below Thakkhola to the south.

### Introduction

During the summer of 1977, Mr. Hans J. Epstein, the expedition leader, his sons Mark and Larry, and I explored steppe and alpine regions of Thakkhola, a high valley of the Kali Gandaki River, and the adjacent Manang and Sangda regions in Himalayan Central Nepal for Palaearctic butterflies. From June 1st to August 7th we collected between 2745 and 5395 m, covering about 965 km of main and minor trails in all. We were ably assisted by Sherpa guides (Danu, head Sherpa) and porters provided by Lt. Col. James Roberts of Mountain Travel, Khatmandu. An historical account of this rarely collected area, along with our papilionid and pierid results, has recently been reported by Epstein (1979a, b). The present report covers the Palaearctic Lycaenidae I collected on the expedition. (Epsteins' collections were for the same species and localities as reported here.) Although two species of Riodinidae and six species of Hesperiidae were encountered in the Oriental-subtropical zones during the expedition. none were seen in the Palearctic zone (Shields, 1981). Climatic, geologic, and biogeographic background information will be discussed.

<sup>&</sup>lt;sup>1</sup>Research Associate in Entomology, Los Angeles County Museum of Natural History

### Climatic Regime of Thakkhola

Thakkhola is the high valley (>3050 m) of the Kali Gandaki River in Central Nepal, a glacial-fed river that originates north of the Himalayan Ridge in the semi-arid region of the Mustang Kingdom. The high, open basin cuts into the Tibetan Plateau and is bordered by two north-south ridges, nearly 6100 m in elevation. A series of tributary valleys, extending about 16 km, drains the ridges. Below this valley, the Kali Gandaki crosses the High Ridge from Dhumu to Dana and Tatopani in a narrow S-shaped gorge cut deeply between Dhaulagiri (8300 m) to the west and Nilgiri (7530 m) to the east. It then descends 1980 m in about 16 km, with the climate changing from Tibetan semi-arid (slopes north of the High Ridge) to Nepali monsoon tropical (south slope). Thereafter, the valley opens and the river flows southernly for about 50 km. Its tributaries drain all the glaciated south slope of the High Ridge (above from Krummenacher, 1971).

During the monsoon season (July to September), the moist air which reaches Nepal from the southwest is forced to rise when it meets the mountains, resulting in heavy precipitation on the southern sides of the Himalayas. Upper slopes around 2440 m are almost perpetually covered with drizzling mist and clouds. When the monsoonal air passes over the northern sides of the Himalayas, there is a pronounced rain-shadow effect. Early October to mid-December is the post-Monsoon or retreating southwest monsoon period. Winter lasts from December to March, when heavy snowfall occurs in the higher Himalayas. Spring extends from April to June (above from Banerii, 1952; Critchfield, 1966; Stainton, 1972).

A strong wind blasts through the gap between Daulagiri and Annapurna and on up the upper Kali Gandaki valley for most of the day, starting around 10 AM during the monsoon season. This wind clears the rainclouds from the center of the valley, while the sides of the valley above 4420 m are usually covered in mist.

In Central Asia, including the Himalayas, there were four glacial periods corresponding to the Mindel, Riss, Wurm, and post-Wurm stages in the Alps (Trinkler, 1930; Mani, 1968). Glaciation was extensive on the northern side of the Himalaya during the Pleistocene, where huge moraines encumbered all the northern valleys. In the Mt. Everest area, these north-side glaciers completely blocked most of the valleys and often were linked (Trinkler, 1930). On the Tibetan Plateau, glaciers were sporadic and small except in southeastern Tibet, and the highland was not covered with a cap of ice (Trinkler, 1930). Today, perpetual snowline in the Himalayas is 4875 m (5180 m in Nepal), and on the Tibetan Plateau it rises to 6100 m due to lack of precipitation. The lower limit of glaciers on Annapurna (south cirque of Annapurna I) is 3600 m, while their upper limit there is 5200 m (Vivian, 1970).

### Geologic Setting of Thakkhola

Nine of the 14 world's tallest mountains, >8000 m high in elevation, occur in the Higher Himalayas of Nepal. Daulagiri (8172 m) is the sixth highest peak in the world. Tibet is the highest of the world's plateaus, averaging 4875 m. The Tibetan slab is an immense monoclinal structure dipping north. Based on indications from submarine volcanism and paleomagnetism, Middle Cretaceous-Eocene was the time when the Himalayan orogeny formed (Verma, 1973; Blow & Hamilton, 1975).

The Inner Himalayas, the region between the Great Himalayas and the Tibetan Plateau, are composed of Lower Paleozoic to Middle Cretaceous marine formations of the Tibetan Zone (Colchen, 1975). Towards the north this zone grades into the Tibetan Plateau across the Nepalese border. Formations of Thakkhola range in age from Precambrian to mid-Cretaceous (Krummenacher, 1971).

Most great rivers of the Himalayas have their source in the Tibetan Zone and cut across the Great Himalayan Range in deep gorges. Below Tukche, the walls of the Kali Gandaki gorge rise from about 2440 m to over 7925 m, making it perhaps the greatest canyon in the world.

A major N-S directed fault zone borders the west side of the Kali Gandaki valley. This fault has a maximum vertical throw of  $\geq$ 2700 m; it sharply cuts all existing structures and is therefore post-orogenic.

### **Biogeographical Affinities**

Elwes et al. (1906) describe the butterfly fauna from the Tibetan Plateau just north of Sikkim and Bhutan (mostly from Gyantze) which appears quite similar to that of the Thakkhola region. Indeed, both areas fall within Ward's (1935) "Outer Plateau" gravel lands botanical division of south-central Tibet. The Chumbi Valley on the Tibetan frontier of Sikkim (Elwes, 1882), about 480 km east of Thakkhola, exhibits a similar fauna to the Thakkhola region. Butterflies from the Kumaon-Tibet border NW of Nepal show close affinities to the Nepal Himalayas (see Champion & Riley, 1926). Other early papers on the Tibetan butterfly fauna include Fawcett (1904), South (1913), and Evans (1915).

In contrast (except for the adjacent Kumaon Himalaya), the butterfly faunas of the high mountains further to the northwest and west of Nepal, though having some species in common with Thakkhola, are fundamentally dissimilar, i.e. the north-west Himalaya (Mani & Singh, 1961-1962), western Karakorum (Evans, 1927), Alai-Pamir (Forster & Rosen, 1940), Baluchistan (Evans, 1932), Afghanistan (Clench & Shoumatoff, 1956; Wyatt, 1961), and West Pakistan and Iran (Shirozu & Saigusa, 1963). Most species of Lepidoptera from Northwest Himalaya are also found in the Pamirs and other Middle Asiatic mountains (Mani, 1968, p.220). This biogeographic division is termed the Turkmenian subregion of the Palaearctic realm and extends over Transcaspia, Turkestan, the Higher

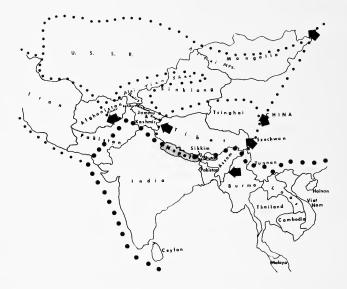


Fig. 1. Butterfly faunal provinces of Southeast Asia. Arrows indicate the initial spread from an Upper Burma-Yunnan-Szechwan center of origin.

Himalayas along the south slopes (above treeline), Tibet, Sinkiang, Mongolia, and southernmost West Siberia (Mani, 1962, 1974). However, the Mongolian butterfly fauna differs markedly from the central Himalayas (see Elwes, 1899; Forster, 1965). Mani (1968, p. 228) sets off Northwest Himalaya, Karakorum, and the Alai-Pamirs as a distinct biogeographic subunit of the Turkmenian. The bulk of the Indian butterfly fauna proper is derived from the Oriental tropics (Holloway, 1969, 1974) (see Figure 1).

The southern boundary of the Palearctic extends to the southern slopes of the Himalayas, between 2440-3660 m in the N.W. Himalayas, gradually rising to 3660-4575 m in the east (Seitz, 1923; Riley, 1927). Tree-line or slightly below tree-line is probably a more realistic boundary in the Thakkhola region.

The alpine flora of the Himalaya is closely related to the alpine flora of eastern Tibet and western China (Kitamura, 1955). In Nepal, the East Himalayan floral elements merge with the West Himalayan elements (Banerji, 1962, 1973), at least in the Oriental realm (Bhatt, 1964). The Thakkhola-Manang regions lie in the Eastern Himalaya in Banerji's scheme but close to this 83° Longitude merging line. We found some basic differences in various butterfly subspecies on the east and west sides of the Kali Gandaki in the Thakkhola region, also in support of this boundary.

The highest known angiosperms collected in Nepal are from just below 6000 m (Webster, 1961).

### Lycaenid Localities (Table 1 and Figure 2)

1. Just north of Jhomosom, 2800 m (Camp 1)

Sophora moorcraftiana Benth. ex Baker var. nepalensis, a pioneer on the steep slopes and new soil along the Kali Gandaki, is the dominant steppe shrub. Also prominent here was Ephedra gerardiana Wall. ex Stapf. This was a very dry, windy valley, like a desert. Jhomosom averages only 270-295 mm rainfall.

2. Between Jhomosom and just south of Kagbeni to Dangarjong, 2760-3140 m (Camp 2 at Dangarjong) (Figure 3)

The trail between Jhomosom and Kagbeni passes along present-day alluvium. S. moorcraftiana and E. gerardiana occur along the Kali Gandaki, and Juniperus walliciana Hook. f. et Thoms. ex Parl. in DC grows sparsely on the hillsides. Thymus linearis Benth. was abundant south of Dangarjong, but we found no lycaenids on it. The Jhomosom, Kagbeni and Dangarjong villages themselves are under cultivation.

3. Pass region 8 km NNW Dangarjong, 4000-4400 m (Camp 3)

We extensively collected in the basin area with rolling hills 1½ km west of this pass. Alpine meadows are found above treeline, above a zone of Betula utilis D. Don and conifer forest in Sangda Valley. Plants here were grasses, Lonicera spinosa Jacq., Sedum, Polygonum, small purple Aster, and many other alpine flowers. The area has been extensively grazed by goats and yaks but was a rich collecting site nevertheless.

4. 11/2-3 km SE Sangda, 4100-4300 m (Camp 5)

We collected in a broad canyon below a limestone ridge and on grassy ridge slopes, south above Sangda Valley. Alpine flowers included pink and white *Polygonum*, yellow *Potentilla* bushes, white edelweiss, and white

Table 1. Species Collected vs. Localities

SPECIES	LOCALITIES												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Albulina orbitulus asiatica			X	X	X	X	x			x	x	X	X
Albulina lehana Polyommatus stoliczkana arene							Λ	X	Δ	X	Λ		
Polyommatus nepalensis		X	X		X	X							X
Lampides boeticus	X					X	47		**				**
Lycaena phlaeas baralacha		X				Х	X	X	X				X
Rapala selira		X											

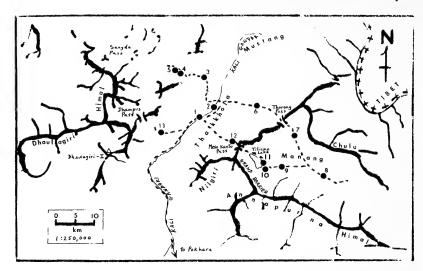


Fig. 2. Map showing our 13 collecting localities in the Thakkhola, Sangda, and Manang regions. Glaciers are stippled.



Fig. 3. Kali Gandaki River Valley with Annapurna in background.

Saxifraga. Upper talus slopes were nearly devoid of vegetation except for Saxifraga. The area was very windy at times and heavily grazed by goats, yaks and horses.

5. 1½ km SW Sangda, 3600 m (Camp 4)

Tibetan steppe vegetation of  $\it Caragana\, gerardiana\, Royle$  and  $\it Artemisia\, grows$  here on shale.

6. Just below sanctuary of Muktinath, 3600-3700 m (Camp 6)

Tibetan steppe vegetation near cultivation was characterized by Ranunculus, Potentilla, Geranium, Stellera, Primula, Thymus, Populus ciliata Wall. ex Royle and thickets of Spiraea and Lonicera.



Fig. 4. Marsyandi River Valley of Manang.

7. 3-10½ km SE Thorong Pass, 4200-4900 m (Camps 8 and 9)

We collected mostly in Jargeng Valley, which consists of limestone. Lush habitat occurred in places along the river, with some alpine meadows and bare rockslides above timberline. Alpine plants included grasses, sedges Gentiana, Primula, Pedicularis, Campanula, Lactura, Brassica, Convolvulus, Rumex nepalensis Spreng., Heracleum, Iris, Ribes, Oxytropis. Thorong Pass is at 5345 m.

8. Manang (3500 m) to valley and slopes 5 km ESE Manang (3370-3700 m) (Camp 11) (Figure 4)

The valley of the upper Marsyandi River is covered by an open xerophile forest of pines (*Pinus griffithi* McClelland in Griffith) and junipers (*Juniperus squamata* D. Don, *J. communis* L., *J. wallichiana*). On

Annapurna III above Braga, this open forest creeps up to 4100 m where it changes into a dense Abies forest, with alpine vegetation above the Abies forest. The extensively cultivated valley consists of alluvial deposits and alluvial fans. Other plants in the region include Ranunculus hyperboreus Rottb., Populus suaveolens, Lonicera myrtillus Hook. f. et Thoms., Pyrus, Vibernum, Oxytropis williamsi Vass., Crataegus, Potentilla and Rosa sericea. Vegetation of the Marsyandi basin is lusher than the arid Kali Gandaki basin. In the Marsyandi, the winds are not nearly as strong, and rainfall is much more frequent during the summer monsoon than in the Kali Gandaki.

9. 6½ km W. Khangsar, upper end Khangsar Valley, 4500 m (Camp 14)

We camped here for 6 days in early July, in rolling alpine pastures on limestone filled with flowers and grasses above timberline. Flowers included a small purple Aster, legumes, purple Viola, a few Sedum, Rumex, Rheum spiciforme Royle, Ranunculus, strawberry, and pink Polygonum. Usually there was very little sun here in early July.

10. 8 km W. Khangsar, 4000 m (Camp 15)

We camped where three rivers converge. Many different alpine plants grew here on limestone, including *Heracleum*, *Polygonum*, *Betula*, bush *Lonicera*, yellow sunflower, grasses, purple Azalea, orchid, purple *Aster*, chives and *Berberis*.

11. SE slopes above Tilicho Lake, 4860 m (Camp 16) (Figure 5)

This isolated lake is located on the N. side of Nilgiri and is surrounded on the south by glaciers. Sparse alpine vegetation of *Sedum*, pink *Polygonum*, purple *Aster*, purple *Gentiana* and some grasses was noted on limestone.

12. "High Camp", NW below Tilicho Pass, 4420 m (Camp 17)

This camp had alpine meadows and dells filled with pink *Polygonum* and purple *Aster*. We followed the North Thini Valley between here and Jhomosom.

13. 5-5½ air km W. Marpha, 3850 m (Camp 22)

We camped and collected at treeline at the NW corner of old, manmade terraced fields surrounded by grassy-juniper slopes. A complex assortment of alpine and temperate forest plants grew here: Juniperus, Sedum, Thymus linearis, Nepeta leucophylla Benth., white Heracleum, orange crucifer, small and bush purple Asters, two yellow composites, Artemisia, yellow Trifolium, pink scroph, grasses, Salix, red thistle, various field weeds, Rosa, conifer and hardwood groves and beech. This locality was rich in butterfly species and flowers with recent glaciations.

Along the Kali Gandaki between Marpha and Lete, there is a *Pinus excelsa* Wall. ex D. Don forest, then 4 km S. of Ghasa starts a broadleaved trees-pine forest, and then the humid, subtropical monsoon forest (Figure 6). Thus in the space of 24 air km S. of Jhomosom to the entrance of the Dhauagiri-Annapurna gap, only about a 915 m drop in elevation, one

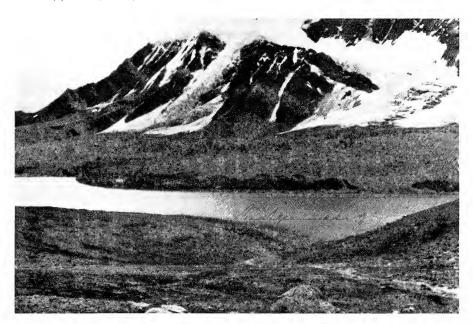


Fig. 5. The Tilicho Lake locality.

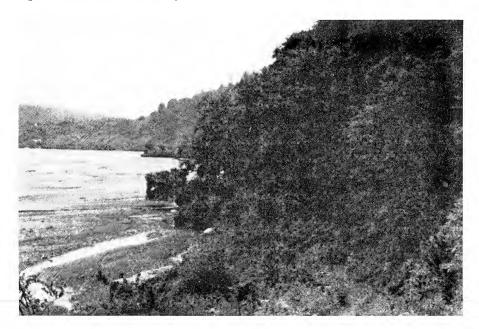


Fig. 6. Subtropical monsoon forest,  $24-32\ km\ SW$  of Marpha.

passes abruptly from Tibetan steppe (Palaearctic realm) into the subtropics (Oriental realm). The transition is much less marked on the valley sides. The butterflies we encountered in the subtropical forest habitat and hardwood trees-pine forest habitat from Kalopani (2440 m) southeast to Pokhara were endemic to the Oriental realm (Shields, 1981). Rapala selira (Moore) appears to be a resident just within the Palaearctic realm, while Lycaena phlaeas (L.) and Polyommatus nepalensis Forster extend down into the Oriental realm.

One additional, Oriental species, *Celastrina dilectus* (Moore) was taken as a fair condition male 4 miles west of Khangsar, 4500 m, July 9. This is doubtless a stray from lower elevations where it is known from the Himalayan foothills from Simla to Nepal.

### Lycaenidae Collected

1.) Albulina orbitulus asiatica (Elwes), 69♂♂ 19♀♀; localities 3, 4, 5, 6, 12, 13; flight in mid June, July.

Males sometimes formed mud puddle clubs of 4-6 individuals. We found a light green pupa under a rock on June 15th that emerged on July 4th, 8-9½ km NNW Dangarjong. Elevation range: 3600-4420 m.

A. orbitulus is found in the Pyrenees and the European Alps at high altitudes, southern mountains of Norway, Lapland, Scandanavia, Asia Minor, the Balkan, Persia, Altai Mts., and Himalaya Mts. to Tibet, northcentral Mongolia, Turkestan, China, and south Siberia as far as Kamtchatka as subspecies or possibly closely related species (Elwes, 1899; Seitz, 1906; Forster, 1965; Higgins, 1975). It is also found in the Amur region (Mani, 1968). A. pheretes Hubn. is a synonym (see Beuret, 1933) and occurs in Tarbagatai, Central Asia. A. o. asiatica (Elwes) is found at high elevations in the northeast corner of Nepal (Riley, 1923; Fujioka, 1970) and Sikkim (Mani, 1968). Elwes et al. (1906) consider ssp. pharis Fawcett to be a synonym of ssp. asiatica and record it from Tungu, Khamba Jong, and Lhanak Valley, Tibet. A. o. pharis (TL = Khamba Jong, 4575 m, Tibet, Fawcett, 1904) is recorded from Phari, 4875 m, and Tinki La, 4725 m (Riley, 1927). Unspecified subspecies of A. orbitulus are found at Girthi Valley, Shibchilan, Chojan and Lal Pahar (Champion & Riley, 1926), Po Chu Valley and Gyala (Evans, 1915), and Tiong la, Zhasha-la, Drowa Gompa, Pugo and Di Chu (South, 1913), all in Tibet. Forster described ssp. lobbichleri from only two worn specimens from Thakkhola; fresh specimens have the greenish gloss to the underside characteristic of asiatica, so lobbichleri is likely a synonym.

2.) Albulina lehana (Moore), 16 or 399 plus 23 others; localities 7, 9, 10, 11; flight in late June to mid July.

Adults flew in meadows, came to moisture, and three were found 10% km SSE Thorong Pass on a large purple *Aster* sp. in meadows in the early morning before it rained. Elevation range: 4000-4860 m.

A. lehana was described from Leh, 3515 m, Ladak (Moore, 1878, p. 230) and is found in Chitral-Kumaon over 3660 m (Cantlie, 1963), Kashmir (Mani & Singh, 1962) and the Pamirs and Kighizia (Korshunov, 1972). Elwes et al. (1906) claim that the West-Tibetan form is lehana. Lowndes (1953) records it ("nr. pheretes") from Manangbot, 3810 to 4875 m, Nepal, July. As orbitulus and lehana occur allopatrically in the Thakkhola region, they are probably separate species.

3.) Polyommatus stoliczkana nr. arene Fawcett, 53°° 22°°; localities 8, 10; flight in late June to mid July, early August.

40 adults were taken in late June, all flying around Oxytropis williamsi Vass. (det. by A. O. Chater, BMNH) with rose-purple flowers and light, hairy leaves. Two females oviposited on the leaf venter at 8:30 and 10:30 AM. One in copulo pair (male carried female) was taken at 9:30 AM. Specimens were fresh to worn and did not visit mud; most alighted on the flowers and leaves of the foodplant. Oxytropis grew mostly on old stream alluvium, i.e. on flats. At 5 km ESE Manang, a dozen adults were taken in close association with O. williamsi growing on flats near pines, some feeding on the flower-heads.

We observed this species generally between Manang and Khangsar. One male was taken 16-19 km SW Marpha (est. 2560 m) in a Thymelegume area of a dry river bed. Elevation range: 2560-4000 m.

This is the "Eumedonia chiron jermyni" of Forster (1961). Nominate jermyni is found from Chitral to Gilgit (Cantlie, 1963). P. stoliczkana was originally named from Ladak. The species is quite variable in size and undersurface markings. According to Mani (1968), it extends from the Northwest Himalaya to the Sikkim-Himalaya, and is represented by the ssp. hunza Gr.-Gr. on the southeast Pamir and in the Great Pamir, at elevations of 3870-4725 m. It is also found in the Western Karakorum (Evans, 1927). P. s. janetae Evans occurs in Karakorum, Khupjerah, Gujerab and Baturu (Wu, 1938), and ssp. ariana Moore is found in North India and southern Kashmir (Seitz, 1906). P. stoliczkana has been taken at Sanga Chu Dzong, southeastern Tibet, 3660 m, in June (South, 1913). Riley (1923) reports it common between June 18 and August 12 from 3960-4570 m on Mt. Everest. Elwes et al. (1906) give Gyantze and Khamba Jong, Tibet, as localities. Evans (1915) records it from Po Chu Valley and Tsang Po, Tibet, from July to September. In Nepal, Lowndes (1953) says it was common in grassy places and among junipers in Manangbot, 3500-4570 m, in July. Shirozu (1955) records it from Annapurna Base Camp to Chame in late May and early October, above 2500 m. The Nepal material we collected agrees with the description and figure of ssp. arene Fawcett (TL = Khamba-Jong, 4570 m, Tibet) (Fawcett, 1904; Seitz, 1906).

4.) Polyommatus nepalensis Forster, common (no exact tally); localities 1, 2, 3, 5, 6, 13; flight in early to mid June, late July to mid August.

Between Jhomosom and 1½ km S. Kagbeni, many were taken in early June, always around the blue-flowering Sophora moorcraftiana var. nepalensis bushes. One in copulo pair was on S. moorcraftiana, male carried female, at 8:00 AM. Just below the sanctuary of Muktinah (3600 m), one female displayed preoviposition behavior on a young, flowerless Lonicera spinosa bush (no Sophora here). At 5½ km W. Marpha (3700-3850 m), adults were in association with Thymus linearis Benth. and Nepeta leucophylla Benth. (both det. by J. R. Press, BMNH), in a Rosa-Juniperus-Artemisia area. Sometimes freshly emerged males were found at mud. We collected a few P. nepalensis in the hardwood-pine zone between Kalopani and Lethe, and between Kalopani (2440 m) and Ghasa (2010 m), in August. Elevation range: 2010-3900 m.

Shirozu's (1955) Polyommatus eros ariana Moore from Tukucha-Jhomosom and nr. Muktinath is probably this species (he doubted the original identification). Wadhi and Parshad's (1968) P. icarus fugitiva Butl. is also suspect, from Tukcha, Marpha and Dana in April. Forster (1961) says P. nepalensis stands near the species everesti Riley (1923) and may be only a subspecies of it.

5.) Lampides boeticus (L.), 300; localities 1, 6; flight in June, late July.

This species is strongly migratory in the west, a resident of S. Europe and N. Africa, Ceylon, India, Pakistan, Nepal, SE Tibet, Szechuan, Andamans, Nicobars, Burma, Australia, Tasmania, Lord Howe Island, etc. It was scarce in the Thakkhola region. There are no recognizable subspecies within its vast range. It is known to use many legumes as foodplants.

6.) Lycaena phlaeas baralacha Moore, 62♂♂ 22♀♀; localities 2, 6, 7, 8, 9, 13; flight in mid June to mid August.

Adults were sometimes found along streams. Two males 6½ km SE Thorong Pass, at a bridge, were very territorial. Adults were also taken in the hardwood-pine zone ca. 24-32 km SW Marpha (2550 m), between Kalopani and Lethe (2530 m), and between Kalopani (2440 m) and Ghasa (2010 m). Elevation range: 2010-4500 m.

According to Ford (1923), baralacha (TL = Baralacha Pass, 4875 m, Ladak) is perhaps a race of stygianus Butler. Distinguishing features between these two are slight and depend upon the amount of FW brown suffusion (more intense in baralacha than in stygianus). L. p. baralacha occurs in the Outer Himalayas (Kashmir-Kumaon), and Nepal, where it is common (in Evans as phlaeas indicus) (Cantlie, 1963). L. p. stygianus inhabits Baluchistan to Chitral and Ladak (= eleus F.; timeus Cr.) (Cantlie, 1963). L. p. flavens Ford is found in the Interior Himalayas to Sikkim and SE Tibet; it is large, with scanty brown suffusion (Cantlie, 1963). Wadhi and Parshad (1968) report L. p. baralacha (= indicus) from Lethe, Tukcha, and nr. Muktinath, Nepal. H. J. Epstein (in litt.) compared the

Thakkhola material with the British Museum collection and concludes it is best placed as baralacha.

7.) Rapala selira (Moore), 9 specimens, cal. 1½ km N. Dangarjong, 3140 m. 3 June 1977.

Mostly fresh specimens were collected in a thicket at the outskirts of cultivation. This locality is Quaternary alluvia (loess and broken rock).

Nominate selira was described from Kashmir (Moore, 1874). It is found in the Western Himalayas, Chitral to Kumaon, Nepal, and Tibet, and is common (= roana Fruh. In Evans it is listed as micans selira, but micans is now regarded as a Chinese ssp. of nissa) (Seitz, 1906; Cantlie, 1963). It flies in April-June, between 1220-2745 m (Wynter-Blyth, 1957). The Dangarjong locality may be a new altitude record (3140 m). Wadhi and Parshad (1968) found this species at Marpha and Jhomosom in late April and early May. The foodplant is Indigofera purpurea (Leguminosae) (Sevastopulo, 1973).

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## Intergradation between Callophrys dumetorum oregonensis and Callophrys dumetorum affinis in Northwestern U. S. (Lycaenidae)

James A. Scott and John A. Justice

60 Estes Street, Lakewood, Colorado 80226 and 1700 Seventh Street NW, Minot, North Dakota 58701

Abstract. Populations of Callophrys dumetorum from the Washington state area are analyzed using seven wing characters. Samples from the Blue Mountains of Columbia County Washington and Wallowa County Oregon are almost exactly intermediate between C. d. oregonensis and C. d. affinis (new combination). C. d. washingtonia (new combination) from the type locality in Okanogan County in northern Washington is also intermediate, but closest to affinis. Eastern Washington specimens from Spokane and Lincoln Counties are intermediate in several traits but are mostly referable to C. d. affinis. These populations and C. d. oregonensis seem to be stages in the intergradation of C. d. dumetorum with C. d. affinis.

## Introduction

The status of names within Callophrys (Callophrys) has been problematical. Tilden (1963) and Clench (1963) made careful studies of Callophrys, but they lacked significant samples of dumetorum (Bdv.) and affinis (Edw.) from the northwest. Scott (1975a), based on small samples collected by Jon Shepard, predicted that C.dumetorum oregonensis Gorelick and C.d.difinis might be found to intergrade in Washington and that C.d.difinis might be found to intergrade population. Adequate samples from Washington have now been obtained by John Justice from four areas of the state. Analysis of these series show a pattern of intergradation between oregonensis and affinis.

### Methods

Individuals were studied from southwestern, northern and eastern Washington, from the Blue Mountains of SE Washington and NE Oregon, and (for *C. d. affinis*) Montana, Wyoming, Nevada, Utah and Colorado. Exact localities and numbers are given in the Appendix. *Callophrys sheridanii* (Carpenter) was caught at most of the localities, but we carefully removed them from the samples before study.

The genitalia do not differ among Callophrys (Callophrys) species. The following wing pattern characters were studied because they are the only characters that differ among the samples: 1) dorsal color (gray to completely fulvous); 2) number of cells with white spots on ventral

hindwing (from 0 to 8); 3) shade of green on ventral hindwing (including several shades of green, bluish green, and vellowish green); 4) ventral hindwing fringe (the fringe base varies from brown to nearly white); 5) number of cells with dark (gray to tan) color on anal margin and disc of ventral forewing (from 2 to 4 cells) (the rest of the wing is some shade of green); 6) the shade of color (varying from gray to tan) at the most anterior extension of the non-green part of the ventral forewing; 7) color of the scales on the costal margin of the ventral forewing (from cream colored to light brown). The character states and cross references to a color manual are given in the explanation for Figure 1. If a specimen had some scale loss. it was compared to the reference specimen for each character state with a microscope to compare the intact scale color; if scale loss was extensive the specimen was ignored. Several other characters mentioned by Tilden (1963) that are useful for distinguishing other Callophrys (sheridanii, viridis (Edw.), etc.) were found to not vary among (and therefore are not useful for distinguishing) the samples studied in this paper: shape of fore and hindwing, color of the frons, number of white rings on the antennae, and antennal color.

## Results

Population phenotypes. Results are shown by histograms (Figure 1). C. d. oregonensis from Klickitat and Yakima Counties Washington (type locality Kusshi Creek, Yakima Co. Washington) and C. d. affinis from Montana south to Colorado and Nevada (type locality vicinity of Fort Bridger, Wyoming, Brown & Opler, 1970) represent extreme populations in most traits, so the other samples will be compared to them. The eastern Washington (Spokane and Lincoln Counties) sample is intermediate between oregonensis and affinis in dorsal color and slightly intermediate in ventral hindwing spotting, it is like affinis in the ventral hindwing color and fringe, and is more extreme than affinis in the three ventral forewing characters; it can be treated as C. d. affinis. The Blue Mountains sample (Columbia Co. Washington and Wallowa Co. Oregon), however, is intermediate between oregonensis and affinis in ventral hindwing fringe, in ventral forewing costa color, and somewhat intermediate in ventral forewing dark color, it is like oregonensis in dorsal color and ventral hindwing color, and it is like affinis in ventral hindwing spotting and number of ventral forewing dark cells. The Blue Mountains population therefore appears intermediate between oregonensis and affinis, and cannot be assigned an available name. The sample from Alta Lake in northern Washington (the type locality of washingtonia Clench) is intermediate between oregonensis and affinis in dorsal color, in ventral hindwing spotting, and in ventral hindwing fringe, it is somewhat intermediate but closest to affinis in the ventral forewing dark color, and it is like affinis in ventral hindwing color, number of dark ventral forewing cells, and ventral forewing costa color. The Alta Lake sample therefore is

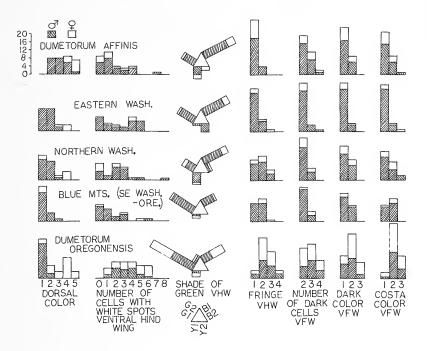


Fig. 1. Histograms showing the number of individuals of each sex from each sample which have each character trait. Colors are from the Color Harmony Manual 1958 (chip number and formal name of color given in parentheses). Character states are 1) dorsal color (1-gray; 2-slightly orange; 3-half orange; 4-mostly orange; 5-completely orange except the margins (chip #5 1a, orange)); 2) number of cells with white spots on ventral hindwing (from 0 to 8 cells have white spots); 3) shade of green on ventral hindwing (G1 green (chip #24 1 c, parrot green); G2-dark green (chip #24 ne, pea green); B1-slightly bluish green (chip #23 ia, light paris green); B2-bluish green (chip #22 ia, brite mint green); Y1-slightly yellowish green (chip #24 ia, light lime green); Y2-yellowish green (chip #24½ ia, brite chartreuse)); 4) fringe of ventral hindwing (1-very light, nearly white; 2-dark band at base of fringe thin, tan in color; 3-dark band thicker, browner; 4-dark band thick and brown); 5) number of cells in anal angle and disc of ventral forewing which have dark non-green color (varying from gray to orangish) (from 2 to 4 cells have dark color); 6) color of this dark area on ventral forewing (1-gray (chip #5 ca, pale peach); 2-very slightly tan (between chips #5 ca & 5 ea); 3slightly tan (chip #5 ea, peach pink))—(ssp. dumetorum not treated in this paper also varies to chip #5 ga, peach, and chip #5 nc, burnt orange); 7) color of the costal margin on ventral forewing (1-cream; 2-ochre; 3-brown).

intermediate as well but appears closer to *affinis* than to *oregonensis*. A few individuals from Alta Lake are bluish green ventrally similar to individuals of *viridis* from coastal California.

Behavior. At Alta Lake C. sheridanii flies about three weeks earlier than C. dumetorum washingtonia. C. sheridanii is found mostly in gullies and hillsides at Alta Lake, whereas C. dumetorum washingtonia males perch on prominent shrubs on hilltops, where they evidently wait for females; two copulating pairs of washingtonia were found on the hilltops. At Alta Lake female washingtonia were found to be rather generally distributed. West of Davenport C. dumetorum nr. affinis perched on low (1-2 m tall) mounds in fairly level sagebrush habitat. In the Blue Mountains of Oregon C. dumetorum occurred on a mountain ridge with sagebrush and Eriogonum. C. d. affinis males commonly perch on sagebrush shrubs on hilltops.

## Discussion

In this paper we treat affinis as a subspecies of dumetorum because the two are allopatric entities that seem to be connected by various intermediate populations, thus qualifying as subspecies. The biology and adult behavior of both are similar as well (Scott, 1975a). C. d. washingtonia is one of the intergrade populations, but it is most similar to affinis. The Blue Mountains sample is almost exactly intermediate between oregonensis and affinis, although two characters are closest to oregonensis and two others are closest to affinis. The simplest explanation of these findings is that these populations are not reproductively isolated and represent subspecies rather than species. We have studied only intergradation between C. d. oregonensis and C. d. affinis. C. d. oregonensis is an intermediate of sorts itself, however, since it too is intermediate between C. d. dumetorum and C. d. affinis in several characters including dorsal color, shade of green on ventral hindwing, number of dark cells on ventral forewing, and the shade of gray to brown on ventral forewing (Gorelick, 1968; Scott, 1975a).

A population tentatively assignable to *C. d. dumetorum*, because it appears identical to California *dumetorum*, occurs in the Puget Sound area of Washington (we examined 3 from Belfair, 200', Mason Co. Washington, 12 May 1970, coll. Jon Pelham).

To be complete we should mention that *C. d. affinis* appears to blend with "apama" (Edw.) homoperplexa Barnes & Benj., so that homoperplexa and apama are almost certainly subspecies of dumetorum also. *C. dumetorum homoperplexa* is nearly identical to California *C. dumetorum* in wing pattern (homoperplexa was not named until 1923, over fifty years after its discovery, because lepidopterists labeled it dumetorum), which suggests that homoperplexa and apama are subspecies of dumetorum, because most Lepidoptera species are based on morphological similarity. Another point of similarity is that dumetorum and homoperplexa are the only Callophrys (Callophrys) that are polyphagous: dumetorum feeds on Eriogonum (Polygonaceae) and Lotus (Leguminosae), homoperplexa on

Eriogonum and Ceanothus (Rhamnaceae) (many ovipositions seen in 1980 by J. Scott). Furthermore, intergrade populations between homoperplexa and affinis seem to occur in south central Wyoming (specimens in the American Museum), in the Gunnison-Delta-Mesa County area of western Colorado, and in southern Utah. Larger samples are needed from these areas to better document the intergradation. C. d. washingtonia, C. d. affinis and some C. d. dumetorum populations tend to mate on hilltops, whereas some C. d. dumetorum populations (especially in southern California) and C. dumetorum homoperplexa tend to mate in gully bottoms (Scott, 1975b).

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## Appendix: Localities Studied

C. d. oregonensis individuals were from the type locality and vicinity in southern Washington: Satus Pass, Klickitat Co., 17 May 1970, 17 m, 18 f; Mill Creek, Yakima Co., 17 April 1970, 2 m, 2 f; Kusshi Creek, Yakima Co., 17 May 1970, 1 f; Fort Simcoe, Yakima Co., 17 May 1970, 1 f (all J. A. Justice). C. d. washingtonia individuals were from the type locality in northern Washington: Alta Lake, Okanogan Co., 2 May 1970, 1 f, 6 May 1970, 4 m, 1 f, 7 May 1970, 6 m, 1 f, 23 May 1970, 5 m, 1 f, 11 June 1967, 5 m, 3 f (all J. A. Justice). A third sample was from eastern Washington: 4 mi. NW Fairchild Air Force Base, Spokane Co., 31 May 1970, 3 m, 1 f; 6.4 mi. N. Davenport, Lincoln Co., 31 May 1970, 21 m, 2 f (all J. A. Justice). A fourth sample was from the Blue Mountains of southeastern Washington and adjacent northeastern Oregon: Trail 2138 from Godman Springs, Columbia Co. Washington, 8 July 1970, 2 m; Skyline Road S. of Godman Springs, Columbia Co. Washington, 8 July 1970, 2 m; 1-5 mi. N. of Bear Canyon Campground, Wallowa Co. Oregon, 9 July 1970, 3 m, 1 f; Forest Service Road N-50, 15 mi, SW Troy, Wallowa Co. Oregon, 21 June 1970, 12 m, 2 f (all J. A. Justice). The sample of C. d. affinis was from southwestern Montana (1 m, 1 f), northwestern Wyoming (3 m, 2 f), central Nevada (4 m), northern Utah (1 m, 3 f), and western Colorado (14 m, 3 f), all collected by J. A. Scott and J. A. Justice.

# Chromosomal Studies in Sixteen Species of Indian Pyralid Moths (Pyralidae)

P. K. Mohanty and B. Nayak

Department of Zoology, F. M. College, P. O. Balasore, Orissa, INDIA 756001

Abstract. The chromosomes of sixteen Indian Pyralid moths collected from different localities of Bhubaneswar were investigated in male germ line cells using smear preparations, with two species studied using squashes. Among the species investigated, eight had n=31 (Antigastra catalaunalis, Crocidolomia binotalis, Dichocrocis punctiferalis, Lamprosema indicata, Lepyrodes neptis, Margorina indica, Maruca testulalis, Pyrausta sanguinalis), two had n=30 (Dichocrocis nilusalis, Galleria mellonella), three had n=29 (Chilotraea infuscatellus, Cnaphalocrocis medinalis, Orthaga exvinacea) and one species each had n=27 (Corcyra cephalonica), n=22 (Tryporyza incertulas) and n=12 (Chilo supressalis) chromosomes. The trend of evolution in chromosome number tends toward the lower numbers from a modal haploid number n=31 of the family as well as of the order. All circumstantial evidence indicates the holocentric nature of the chromosomes. The sex-chromosomes in the males are not differentiable, but delayed anaphasic movement of a pair might represent the sex-chromosomes.

## Introduction

In spite of intense work carried out during recent years, chromosome studies in Lepidoptera have not made much headway. Of the 130,000 described species of Lepidoptera only 1,300 species have been chromosomally examined, mostly by de Lesse, Suomalainen and Saitoh (c. f. Robinson, 1971). Most work has been concerned with the chromosomes of butterflies, which constitute only 10% of the total species. Moths, forming the majority of species, have been but less attended. Information on chromosome counts of Indian moths is very meagre at present (Gupta, 1964; Rishi, 1973; Nayak, 1975), though some data on a number of Himalayan butterflies are available (Maeki & Ae, 1966; Saitoh & Abe, 1969, 1970 a, b). Of the family Pyralidae, chromosome numbers of 56 species have been reported. The present note deals with the chromosome counts of 16 species of Pyralid moths, of which 12 are reported for the first time.

## **Materials and Methods**

The present investigations were carried out on testes material from late larvae (5th instar) and early pupae collected from their respective

hostplants. Table I gives the account of hostplants and time and place of collection of the different species of Pyralids. The cytological preparations were made by the following procedure: hypotonic treatment of testes (in 0.9% sodium citrate) for about 10 minutes; fixation in aceto-alcohol (1:3) overnight; preparation of smears on pre-warmed albuminised slides using a drop of 45% acetic acid and finally stained in Heidenheins iron haematoxylin.

## Table I

List of species examined, with foodplant and date of collection given. All were taken in Bhubaneswar.

Species	Foodplant/Resource	Period of Collection
Antigastra catalaunalis Dup.	Sesamum indicum	August, 1976
Chilotraea infuscatellus Sn. (Sugarcane stem borer)	Saccharum officinarum	October, 1977
Chilo suppressalis Walk.	Oryza sativa	March, 1978
Cnaphalocrocis medinalis Guen.	Oryza sativa	October, 1977
Corcyra cephalonica Staint. (Rice moth)	Flour	March, 1976
Crocidolomia binotalis Zell.	Brassica sp.	December, 1977
Dichocrocis nilusallis Walk.	Michelia sp.	August, 1976
Dichocrocis punctiferalis Guen.	Ricinus communis	September, 1977
Galleria mellonella Linn. (Wax moth)	Bee-hive	October, 1977
Lamprosema indicata Fabr.	Glycin max	November, 1978
Lepyrodes neptis Cram.	Nyctanthes sp.	September, 1978
Margorina indica Saund. (Pumpkin caterpillar)	Trichosanthes anquina	August, 1977
Maruca testulalis Gey.	Unidentified	July, 1977
Orthaga exvinacea Hmps. (Mango shoot-webber)	Mangifera indica	January, 1976
Pyrausta sanguinalis Linn.	Ocimum basilicum	July, 1976
Tryporyza incertulas Walk. (Rice stem borer)	Oryza sativa	November, 1978

### Observations

Antigastra catalaunalis Dup. (Figs. 1 to 3). A chromosome count in spermatogonial metaphase cells revealed the diploid chromosome number as 2n=62. Metaphase I normally showed 31 bivalents. The data are based on 70 metaphase I cells in four specimens. Quite often, one bivalent, presumably the sex-bivalent, appeared to be still undercondensed and was in the form of a ring while others were at their maximal condensation.

A number of cells were observed in which almost all the bivalents had been resolved into univalents except a few which exhibited dumbbell-shape with a distinct notch along the median line. In late anaphase I, all except one bivalent separated into their homologues and passed to their respective poles while components of the laggard still remained on the equatorial region. Metaphase II showed 31 univalents. The haploid chromosome number was, thus, confirmed to be n=31.

Chilotraea infuscatellus Sn. (Figs. 4 to 6) 2n = 58. Examination of 101 metaphase I cells in 10 specimens showed 29 bivalents in each. The majority of bivalents separated into univalents at anaphase I and passed to their respective poles synchronously. However, in some cases homologues remained still attached to each other by one or two interzonal fibres at their ends and were pulled apart in characteristic V-shapes. As the chromosomes reached the poles of the spindle, they became split into their chromatids before they formed daughter nuclei and much before telophase I. Metaphase II confirmed the haploid number as n = 29.

Chilo suppressalis Walk. 2n = 24. In counts of 46 cells in six specimens, metaphase I cells showed 12 bivalents each. In certain anaphase I cells, a pair of small deeply stained equal sized bodies were visible on the equatorial region of the spindle when all other partners had nearly reached their respective poles. Metaphase II showed 12 univalents (Figs. 7 to 9).

Cnaphalocrocis medinalis Guen. (Figs. 10 to 12) 2n = 58. Metaphase I cells showed 29 bivalents, out of which one very often resolved early into its homologues showing 30 chromosomal elements instead of 29. Metaphase II cells showed 29 univalents. Seventeen cells in two specimens were examined.

Corcyra cephalonica Staint. (Figs. 13 to 15) 2n = 54. Metaphase I cells showed 27 bivalents each. This has been determined by scoring 66 cells in nine specimens. In some cells, early resolution of a number of bivalents into univalents occurred much before the onset of anaphase. A good number of polyploid cells with double the number of bivalents were also noticed. In two such cells almost all the bivalents showed early separation, but the partners of each bivalent remained in close proximity to each other without any actual contact between them. At anaphase I, all bivalents separated into their equal sized homologues simultaneously. Metaphase II cells showed 27 univalents.

Crocidolomia binotalis Zell. (Figs. 16 to 18) 2n=62. A chromosome count in 59 cells in five specimens established the haploid chromosome number as n=31. However, a large number of these cells showed 30 bivalents and two univalents, while few others also contained an admixture of bivalents and univalents. Anaphase I cells showed the normal disjunction and synchronous separation of the univalent chromosomes along the spindle. Occasionally, however, one of the bivalents lagged on the equatorial plate. Preparations from one specimen contained a faintly

stained chromosome (smaller than the usual sized elements), which remained off the plate. In anaphase I, this element showed precocious pole-ward movement to only one of the poles and most likely is the supernumerary m-chromosome. Metaphase II showed 31 univalents.

Dichocrocis nilusallis Walk. (Figs. 19 to 21) 2n = 60. Metaphase I cells showed 30 bivalents, one of them being distinctly smaller. This has been determined after examination of 30 cells in four specimens. Certain cells of the cyst showed 31 chromosomal bodies including the two smaller elements lying in pair, these may represent resolved homologues of a bivalent. Some early anaphase I cells were also observed with incomplete separation of the components of some bivalents. Again, in a good number of anaphase I cells of a cyst, components of a bivalent trailed behind in their pole-ward movement. Metaphase II showed 30 spherical univalents.

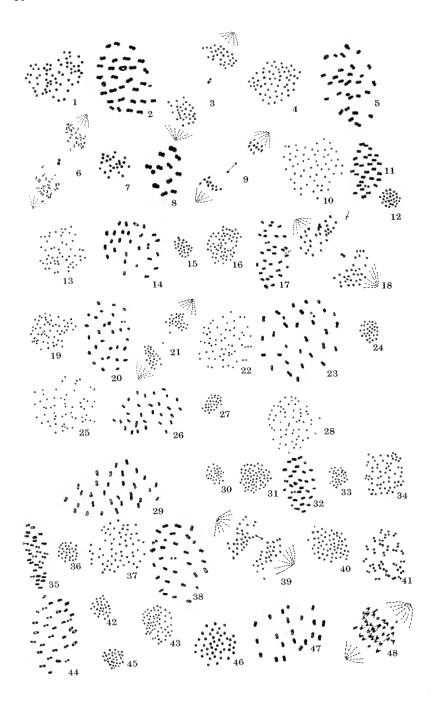
Dichocrocis punctiferalis Guen. (Figs. 22 to 24) 2n = 62. Examination of 126 cells in seven specimens showed metaphase I cells to contain 31 bivalents in each. Anaphase I indicated lagging movement of a bivalent which still remained on the equatorial plate when all others had their homologues passed to their respective poles. Many late anaphase plates also exhibited the laggard on the bridge of the spindle fibres joining the daughter nuclei under formation. Metaphase II cells showed 31 bivalents.

Galleria mellonella Linn. (Figs. 25 to 27) 2n=60. Examination of 71 cells in nine specimens showed metaphase I cells to contain 30 bivalents each. Eleven tetraploid cells with double the number of bivalents also were observed. Anaphase I was normal, but occasionally presented the atypical lagging behaviour of two of the separating elements. Metaphase II showed 30 univalents.

Lamprosema indicata Fabr. (Figs. 28 to 30) 2n = 62. Metaphase I, as determined by examination of 152 cells in 13 specimens, showed 31 bivalents. One isolated giant pupal cell was observed that was a tetraploid in showing 62 bivalents. Some anaphase I cells showed the lagging behaviour of a pair of small deeply stained equal-sized chromosomal bodies. Metaphase II cells showed 31 univalents.

Lepyrodes neptis Cram. (Fig. 31 to 33) 2n = 62. Examination of 55 metaphase I cells of ten specimens revealed 31 bivalents in each. In a number of cells almost all the bivalents were found to be resolved into their homologues. Several tetraploid cells with double the number of bivalents were also encountered. Some anaphase I cells showed a pair of deeply stained equal-sized bodies (the homologues of a bivalent) on the equatorial region of the spindle when all other chromosomes had almost reached the poles. Metaphase II cells showed 31 univalents.

Margorina indica Saund. (Fig. 34 to 36) 2n = 62. Metaphase I cells showed 31 bivalents as determined by counting 17 cells in three specimens. Preparation from late pupal testes showed the homologues of many bivalents remained in closely placed pairs along with a few intact



- Figs. 1 to 3. Spermatogonial metaphase, metaphase I and late anaphase I of Antigastra catalaunalis.
- Figs. 4 to 6. Spermatogonial metaphase, metaphase I and anaphase I of Chilotraea infuscatellus.
- Figs. 7 to 9. Spermatogonial metaphase, metaphase I and anaphase I of *Chilo suppressalis*.
- Figs. 10 to 12. Spermatogonial metaphase, metaphase I and II of Cnaphalocrocis medinalis.
- Figs. 13 to 15. Spermatogonial metaphase, metaphase I and II of *Corcyra cephalonica*.
- Figs. 16 to 18. Spermatogonial metaphase, metaphase I with m-chromosome and anaphase I with m-chromosome passing to one pole forming an extra plate of *Crocidolomia binotalis*.
- Figs. 19 to 21. Spermatogonial metaphase, metaphase I and anaphase I of Dichocrocis nilusallis.
- Figs. 22 to 24. Spermatogonial metaphase, metaphase I and II of Dichocrocis punctiferalis.
- Figs. 25 to 27. Spermatogonial metaphase, metaphase I and II of Galleria mellonella.
- Figs. 28 to 30. Spermatogonial metaphase, metaphase I and II Lamprosema indicata.
- Figs. 31 to 33. Spermatogonial metaphase, metaphase I and II of Lepyrodes neptis.
- Figs. 34 to 36. Spermatogonial metaphase, metaphase I and II of Margorina indica.
- Figs. 37 to 39. Spermatogonial metaphase, metaphase I and anaphase I of *Maruca testulalis*.
- Figs. 40 to 42. Spermatogonial metaphase, late abnormal metaphase I cell and II of *Orthaga exvinacea*.
- Figs. 43 to 45. Chromosomes of Pyrausta sanguinalis.
- Figs. 46 to 48. Spermatogonial metaphase, metaphase I and early anaphase I of *Tryporyza incertulas*.

bivalents. Several anaphase I cells showed homologues of a bivalent right on the equatorial region when all others had their separated homologues moved towards poles. Metaphase II showed 31 univalents.

Maruca testulalis Gey. (Figs. 37 to 39) 2n = 62. Examination of 60 metaphase I cells showed 31 bivalents in each. Early separation of a bivalent into its homologues was noticed in some cells. Some anaphase I cells had two of the homologues of a bivalent on the equatorial position when all others had their separated homologues on the march to the poles. Metaphase II cells showed 31 univalents.

Orthaga exvinacea Hmps. (Figs. 40 to 42) 2n = 58. Metaphase I cells showed 29 bivalents as revealed from examination of 85 cells in six specimens. Some of anaphase I cells showed the lagging behaviour of two separating elements of a bivalent. Even at this stage, prior to metaphase II, which followed without interphase, dissociation of separate homologues into chromatids had occurred. Metaphase II cells showed 29 univalents.

Pyrausta sanguinalis Linn. (Figs. 43 to 45) 2n = 62. Metaphase I cells showed 31 bivalents, as determined from 161 cells in 18 specimens. Early separation of a bivalent to its homologues was marked in several cells. Anaphase I was normal. Metaphase II cells showed 31 univalents.

Tryporyza incertulas Walk. (Fig. 46 to 48) 2n = 44. Metaphase I cells showed 22 bivalents in each of the 106 cells counted in six specimens. In one cyst, majority of metaphase I cells showed early separation of a number of bivalents into their homologues. Some cells had all bivalents resolved much before the onset of anaphase I. In early anaphase I cells, the majority of bivalents separated into univalents and migrated to each pole of the spindle synchronously, although some remained attached to each other by interzonal fibres and were pulled apart in characteristic V-shapes, showing bend between arms, giving the impression of the occurrence of a localised centromere. Late movement of homologues of a bivalent was also marked in late anaphase I cells. The chromosomes divided into their respecitive chromatids as they reached the poles. Metaphase II cells showed 22 univalents.

## Discussion

The Pyralid karyotype is typical of Lepidoptera in general. Numerous small chromosomes, ill defined meiotic stges, anomalous nature of the centromere and sex chromosomes render karvological analysis obviously difficult. The chromosomes at spermatogonial mitoses are all homomorphic and isodiametric bodies without well defined morphological details. The early meiotic prophase is diffuse, and a clear delineation of leptotene and zygotene is not possible due to the appearance of a characteristic 'synizesis' stage rendering morphology and exact nature of pairing of the chromosomes almost obscure. However, the manifestation of the normal process of lengthwise pairing and parallel conjugation of chromosomes cannot be doubted since in the following pachytene a haploid number of thick paired chromosomes forming bivalents became evident. The diplotene for the most part is 'diffuse' and typical diplotene configuration cannot be seen due to decondensation of the chromosomes which practically recede back to the interphase condition. Thus chiasma analysis is difficult although chiasmata do exist. Chiasma become clear only when some condensation takes place towards late diplotene and diakinesis, when mostly they are terminal or near terminal. Interstitial chiasmata with varying distances from ends producing typical cross configuration are also observed. Ring configurations with double chiasmata are seen occasionally. In reduction metaphase, the bivalents are evenly distributed and lie well separated from each other. They are dumbbell-shape in a side view and oval in polar view.

Although uniformity in chromosome size is a well-defined feature of Lepidopteran karyotype, slight gradation in size among the chromosomes are nevertheless evident. Direct correlation between chromosome size and number is indicated since species with low chromosome number have larger chromosomes than those with higher number.

While the majority of authors furnish experimental evidence that Lepidopteran chromosomes are holocentric, with diffuse centromeric activity along the entire length of the chromosome (Bauer, 1967; Suomalainen, 1969; Murakami & Imai, 1974), Bigger (1975, 1976) and Rishi (1978), through the use of improved cytological techniques, claim to have demonstrated the presence of a localised centromere in such chromosomes. The current study, however, lends much support to the holocentric nature of Lepidopteran chromosomes. This conclusion is based on behaviour during metaphase I when the spindle fibres are attached to many points on the conjugated chromosomes and no constriction is marked on any of the chromosomes during their anaphasic movement in the majority of species investigated. Indeed during no part of the meiotic cycle is there any evidence of the presence of a localised centromere. The observation is particularly evident in the meiotic prophase where usually the chromosomes are less spiralised and are elongated providing a better display of their linear structure. However, the appearance of a few 'V' shaped chromosomes, similar to centric chromosomes in anaphase I of C. infuscatellus and T. incertulas, is an exception and the occurrence of a localised centromere, at least on those chromosomes showing the bend, is indicated. Bigger (1975, 1976) demonstrated definite constriction on all the mitotic chromosomes of certain Lepidopteran species-Pieris brassicae, Pieris napi, Polyommatus icarus and Pyronia tithonus—by employing a new air drying technique combined with ASG banding. According to him at early metaphase the chromosomes of Lepidoptera exhibit a monocentric type of organisation, or at least a part of the diffuse centromere (the primary centromere) which exerts dominant influence over the rest. As metaphase progresses the influence of the primary centromere is either lost or superseded by the combined influence of the rest of the diffuse centromere. Thus, according to Bigger, a primary centromere functions only for a limited part of the meiotic cycle later to be superseded by diffuse centromeric activity along the whole length of the chromosome in Lepidoptera. The primary centromere performs the function of holding the chromatids together at prometaphase and its disappearance at metaphase reflects the evolutionary change from monocentric to holocentric chromosomes. Here we may record Schrader's

(1936, 1939) view of cyclic alternation of centromere from diffuse organisation in late prophase to a strictly localised one at metaphase in Amphiuma. Rishi (1978) demonstrated occurrence of a localised centromere in normal diplotene and diakinesis and metaphase I cells of Trabla vishnu. Bauer (1967) expressed the opinion that cumulative evidence swung in favour of evolution of holocentric chromosomes from monocentric ones. If so, the few bent chromosomes indicating primary centromeric organisation during present work are the 'relict' providing further supporting evidence in this regard.

Out of the 16 species reported herein, eight species show the haploid number as n=31 (A. catalaunalis, C. binotalis, D. punctiferalis, L. indicata, L. neptis, M. indica, M. testulalis and P. sanguinalis), two species have n=30 (D. nilusallis and G. mellonella), three species with n=29 (C. infuscatellus, C. medinalis and O. exvinacea), one species with n=27 (C. cephalonica), one with n=22 (T. incertulas) and one has n=12 (C. suppressalis). Thus the observed trend appears toward the evolution of lower chromosome numbers which must have been achieved through chromosomal fusion. The familiar range of variation, however, lies between n=10 as in Perinephala coronata (Bigger, 1960) to n=41 Haritala ruralis (Bigger, 1960). Polyploidy as a means of numerical increase of chromosome number in some Lepidopterans, hypothesized by Lorkovic (1941), appears to have been excluded here since the established chromosome numbers do not fall into any of a common number. We share the same view as held by White (1973) and Suomalainen (1969), that

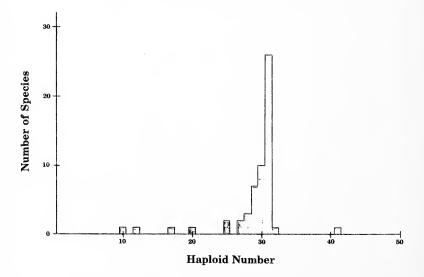


Fig. 49. Histogram showing haploid chromosome numbers in family Pyralidae.

fusion and dissociation are responsible for evolution of chromosome number in Lepidoptera rather than polyploidy, and that fusion is more frequent than fission since there are more species with numbers below 31 than there are ones with numbers above 31. Other factors responsible for an apparent increast in chromosome number include failure of synapsis, early resolution of one or more bivalents to univalents, and the occurrence of one or more supernumerary chromosomes as seen in D. punctiferalis. Out of the 56 species of Pyralids cytologically examined so far, the majority (26) of species show a haploid chromosome number n=31. This is in accord with the standard Lepidopteran karyotype with the modal haploid number n=31. Since the sex-chromosomes are not differentiable, most of the conclusions in this regard are inferential. In the anaphase I of some species, a pair of chromosomes which show delayed poleward segregation may represent the XX sex-chromosome pair of the male Lepidoptera.

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# The Biological and Systematic Significance of Red Fecal and Meconial Pigments in Butterflies: A Review with Special Reference to the Pieridae

Arthur M. Shapiro

Department of Zoology, University of California, Davis, California 95616

Abstract. Red fecal pellets produced just before pupation and red meconium voided by teneral adults are distributed in specific butterfly lineages and may be useful in taxonomy. The red pigments are ommochromes; a brief review of their biosynthesis and physiology is presented. Abnormal production of red ommochromes may follow various disease processes and injuries in Pierid early stages.

The topic of "red rain" was introduced to several generations of American Lepidopterists by W. J. Holland, who reproduced on pages 299-303 of *The Butterfly Book* (1898) an essay on the subject by Frank Cowan. Those who rear Nymphalini are familiar with the bright red meconium which inspired superstitious terror among the European peasantry, but the literature treating the chemistry and physiology of this phenomenon is generally unknown to Lepidopterists, and the potential significance of red excretory pigments in butterfly systematics remains virtually unremarked. This paper presents a brief survey of these subjects, with some hitherto unpublished information on the phenomenon as it occurs in various Pieridae.

Meconium—the material voided upon or shortly after eclosion by a teneral (immature adult) insect—is often pigmented; the color may be characteristic of the taxon. Red meconia are best known in the Nymphalini, in the "tortoiseshell" group of genera variously known as Nymphalis, Aglais, Inachis, Vanessa, etc. (In this paper American rather than European taxonomic conventions will be followed.) They also occur in some other Nymphalid genera which are not closely related, such as Euphydryas and Charaxes. There appear to be very few mentions of fecal or meconial colors in the literature of butterfly breeding. According to one anonymous reviewer of this paper, red meconia occur in the Papilionid genera Parnassius (Tadumia) and Allancastria; P. clodius sol Bryk and Eisner from Nevada County, California, has pink meconium (Shapiro, unpublished). In the Pieridae they are widespread but not universal in the Pierini and Anthocharini (= Euchloini).

## **Chemistry and Normal Biosynthesis**

Meconium is regarded as the waste products of metamorphosis. There are two phases of meconium production in the teneral adult (Lafont and Pennetier, 1975). In the first, red pigments—ommochromes—and uric acid are excreted; the second, which is essentially colorless, contains allantoic acid. Many other compounds have been identified in meconium, but we are concerned primarily with the ommochromes, a group of pigments best known from insect eyes, whence the name. They were reviewed in depth by Linzen (1974), from which much of this section is abstracted. Ommochromes (Fig. 1) are degradation products of the amino

Fig. 1. Structural formulae of the precursor amino acid, tryptophan (A) and its derivatives ommatin D (B) and rhodommatin (C), the two common red excreory pigments found in Pierid and Nymphalid meconia. The biosynthetic pathways are given in detail by Linzen, p. 123.

acid tryptophan. In the Nymphalini two ommochromes, ommatin D and rhodommatin, occur as wing pigments as well as in meconium. The same pigments have been recovered from the meconia of the Palearctic Pierids Aporia crataegi L. and Pieris brassicae L., in the latter only in very small amounts. Ommochromes seem unreported from Pierid wings. They were first obtained in large quantities by Becker (1942) and Butenandt et al. (1954) from the meconium of the European Small Tortoiseshell, Nymphalis (Aglais) urticae L. In the Red Admiral, Vanessa atalanta L., up to 130  $\mu$ g of rhodommatin and 115  $\mu$ g of ommatin D have been recovered from the meconium of a single animal; in A. crataegi these values are 244  $\mu$ g and 225 $\mu$ g respectively. Linzen summarizes the history of these compounds in the insect as follows (pages 176-177):

These ommochromes are formed early in metamorphosis. They make their first appearance at the time when the larvae leave the food and crawl about to find a suitable place for pupation. In (Nymphalis) urticae, orange pigment appears in the midgut wall at the time when the larva is spinning the small web to hang itself up. Twelve hours later, at the time of pupation, the gut is filled with red fluid containing about  $50 \mu g$  each of rhodommatin and ommatin D.

More is known in certain moths. In Ptychopoda seriata Schrk. (Geometridae) and Cerura vinula L. (Notodontidae), studied by authors cited

in Linzen's review, ommochromes appear twice during development, as they do in Pieridae. First they appear in the Malpighian tubules, which excrete them—contributing to a red color in the last few fecal pellets prior to pupation. Later (after pupation), during the reconstruction of the tissues, ommochromes appear in vacuoles of the new midgut epithelium and are released into the lumen of the gut, where they contribute to the first meconium of the teneral adult.

The only definite adaptive function of these releases is the removal of excess tryptophan, but they may serve subsidiary functions as well. In many Lepidoptera meconium is retained by the teneral adult until it is ready for flight, or even longer, but it may be released early if the animal is disturbed. Such releases are often forceful, with a definite potential for defense against predation. Meconium has not, to my knowledge, been examined for repellent or noxious properties. It is perhaps not too farfetched that the blood-red color of first meconium forcibly voided in such circumstances by the otherwise defenseless teneral adult may be alarming or at least distracting to vertebrate predators having color vision.

## Distribution in the Pieridae

In the Holarctic pierine fauna the last few (1-4) fecal pellets produced before pupation, and the first meconium of the adult, are red in certain lineages and not in others; the two seem always to be coupled. These facts suggest that they may be useful characters for phylogenetic reconstruction and higher classification. The only previous use of meconium in taxonomy appears to be by DeBach *et al.* (1978), working on *Aphytis* spp. (Hymenoptera, Aphelinidae).

Ommochrome-excreting Holarctic pierines belong to the Pieris (Synchloe) callidice Hbn. species-group, all of whose taxa thus far examined (callidice, protodice Bdv. & LeC., occidentalis Reak., nelsoni Edw.) show the phenomenon. Meconia are unreported in the formal literature for the closely related subgenus Pontia and for the enigmatic P. (Pontia?) sisymbrii Bdv., but one of the anonymous reviewers of this paper reports red meconia for the Palearctic P. (Pontia) daplidice L. and glauconome Klug. No red ommochromes are found in feces or meconium of the P. rapae L. and P. napi L. species-groups (subgenus Artogeia) except under pathological circumstances (see below), and they are present but scarce in P. (Pieris) brassicae. The highest levels ever measured occur in Aporia crataegi and in some of the South American taxa discussed below.

In the Andean-Patagonian group of Pierid genera, red fecal pellets and meconia seem generally distributed in the *Tatochila-Phulia* series. Taxa reared by me, all of which show the phenomenon, are *Reliquia santamarta* Ackery and the following entities in *Tatochila: sterodice* species-group: sterodice Stgr., arctodice Stghr., macrodice Stgr., vanvolxemii Capr., mercedis Esch.; xanthodice species-group: xanthodice Lucas; autodice

species-group: autodice Hbn., blanchardii Butl. Quantities are especially large in the sterodice group.

In the Anthocharini, red feces and meconia occur in the Holarctic Euchloe ausonia species-group: ausonia ausonia Hbn., a. crameri Butl., and ausonides Lucas (several segregates). They are pink in Anthocharis sara Lucas and Euchloe hyantis Edw. Red excreta are recorded formally in only one Coliadine species; Eurema hecabe L. (Fukuda et al., 1972), but are reported by the aforementioned reviewer of this paper to occur in both Catopsilia and Gonepteryx.

The distribution of red feces and meconia in Pierini and Anthocharini corresponds to the distribution of "red" eggs (Shapiro, 1981). This at least suggests the possibility that the red pigment developed by maturing Pierid eggs might be an ommochrome, since Horowitz (1940) and Horowitz and Baumberger (1941) found that eggs of the marine Echiuroid worm *Urechis* undergo color changes similar to those of Pierids. In this case, the ommochromes function as respiratory pigments; the color change indicates a shift from the oxidized to the reduced state. The well-known color changes of *Euchloe* prepupae (from gray-violet and yellow to pinkish gray in *E. ausonides*, from green to lurid purple in *E. hyantis*) may also be mediated by ommochromes.

The taxonomic distribution of ommochromes as excretory pigments in Pieridae corroborates the conventional phylogenetic interpretation of the Andean-Patagonian fauna (Shapiro, 1980): post-Pliocene derivation from a Holarctic ancestor of the *Synchloe* type. It also supports the electrophoretic evidence of Courtney (1980) and Geiger (1981) indicating a close relationship between *Pontia* and *Synchloe* on one hand and the Anthocharini on the other. This raises the serious question of whether the bizarre Andean *Eroessa* is really an orange-tip at all. It has been considered the most primitive member of that group, but that interpretation would remain tenable only by deriving the Pierini from *Euchloe* or something near it, an unlikely scenario on various grounds.

Phylogenetic interpretation in the Pieridae is complicated by an obvious predisposition to parallelisms and convergences which makes even cladistic reasoning highly unsatisfying. The distribution of excretory ommochromes parallels phenotypic resemblances which have usually been interpreted as superficial and convergent. Both types of characters could have evolved as correlates of dietary specialization (on inflorescences and infructescences); if tryptophan loads are heavier in the diets of these groups than in those of leaf-feeders, physiological parallelism or convergence would be implied. It must be stressed that there is no a priori reason why biochemical characters should be less prone to convergence than morphological ones.

## **Ommochromes in Pathological Contexts**

Linzen (1974, p. 177) observes that ommochromes may be produced

when insects or their tissues "are maltreated so as to disrupt normal metabolic function...it is assumed that under these circumstances the animals draw on their protein reserves as an energy source, thus leading to an excess of tryptophan." Phenomena of this sort are readily observed in Pieridae.

Pierid breeders eventually make the acquaintance of "red dribble disease," a condition of unknown etiology which attacks fourth- and fifth-instar larvae with invariably fatal results. The afflicted larva suddenly stops feeding and begins producing a more or less constant dribble of bright red diarrhea. It never feeds again, but may live for several weeks, shrinking all the while as it consumes its reserves. Most afflicted larvae spin a great deal of silk and may appear to be prepared to pupate, but fail to do so. The condition is associated with etiolated food, with certain Crucifers which are edible but apparently inimical to survival (such as flowering tops, but not rosettes, of the weed Barbarea vulgaris R.Br.), and with inbreeding depression in long-term cultures; it does not seem to be infectious or contagious. I have encountered it in cultures of Pieris (Synchloe) and of Tatochila and—interestingly—of P. rapae and P. napi, which do not ordinarily produce visible quantities of excretory ommochromes.

Prepupae of *Tatochila* placed at 37°C or higher become ssuffused with pink, which carries over into the pupa but fades gradually over several days if the pupa is returned to 25°C. Diseased pupae of *Pieris (Synchloe)* and *Tatochila*, but not *Pieris (Artogeia)*, often develop a red "saddle" in the mid-dorsum which may spread over the entire body, but not the wingcases; such pupae never recover and are found to contain a bacterial broth. Pupae of *Euchloe ausonides* and *hyantis* develop a characteristic rosecarmine flush if diseased or attacked by parasitoids. The flush starts in one area and gradually spreads over the abdomen as more tissues become involved. Heat-shocked pupae of Nymphalini which are killed by the treatment generally turn purple-pink. All of these phenomena are suspected to involve abnormal ommochrome synthesis.

Abnormal failure to produce excretory ommochromes is also observed in from less than one percent to five percent of Pierini in mass culture; only the second (colorless) meconium is excreted. This phenomenon is observed both as scattered individuals in large broods and as clusters of sibs from particular families. The implication of genetic variation in the ommochrome pathway suggests caution in using evidence from one or a few reared examples in a typological way for taxonomic purposes. Nonetheless, the usefulness of these pigments in classification and the understanding of their function would benefit if more breeders would record the color, if any, of the final larval feces and meconia of whatever species they have in culture, and publish this information.

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American work contributing to this paper was funded by the National Science Foundation (DEB-76-18611), the National Geographic Society, and the UCD Institute of Ecology. Two anonymous reviewers of the paper provided useful suggestions, the Fukuda reference (which is in Japanese), and unpublished information on the distribution of red meconia in some Palearctic genera.

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# On the Nomenclature of Colias alfacariensis Berger 1948 (Lepidoptera: Pieridae)

Otakar Kudrna

Zoologisches Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 150-164, D-5300 Bonn 1, Germany

**Abstract.** The nomenclature of the butterfly usually called *Colias australis* is discussed in chronological order, with comments regarding the relevant papers published by other authors. The valid name for the species, its author and date of publication are established, this being *Colias alfacariensis* Berger 1948.

"Berger's Clouded Yellow" has usually been called "Colias australis" and its authorship has usually been attributed to "Verity 1911." However, two other names—"Colias alfacariensis" and "Colias calida"—have also been used for the species, and their authorship attributed mainly to "Ribbe, 1905" and "Verity, 1916", although some other authors have also been occasionally quoted, e. g. Berger, 1948; Berger & Fontaine, 1948 and Verity, 1923. Kocak (1981) in his painstaking examination of the nomenclature of the European butterfly species, was already fully aware of the unavailability of the name australis in connection with Verity's authorship dated 1911 (Verity, 1905-11); Kocak apparently presumed that the name australis was made available later, elevated to the speciesgroup rank by an unspecified author at an unspecified date to become the senior subjective synonym, and consequently the valid name, for the species. Dutreix (1981) retained the name and authorship as "Colias australis Verity 1911" but his useful compilation of the literature on the species helped in the search for the correct name of the species. Blab & Kudrna (1982) already employed the correct name, author and date of publication Colias alfacariensis Berger 1948; they did not explain the reasons behind their action as to do so was beyond the scope of their work.

A chronological order has been chosen as being the most opportune method to elucidate the complex taxonomic and nomenclatural history of "Berger's Clouded Yellow." Throughout the paper on several occasions a reference is given to the International Commission on Zoological Nomenclature and to the International Code of Zoological Nomenclature; to save space the former is abbreviated ICZN and the latter simply "Code". I have the pleasure of thanking R. V. Melville (ICZN, London), G. Bernardi (Museum National d'Histoire Naturelle, Paris), A. O. Kocak (Ankara University, Ankara) and Ichiro Nakamura (USA) who at various times

discussed with me some aspects of zoological nomenclature and/or provided valuable advice which in part concerned also some problems related to this paper.

Ribbe (1905) described an aberration of Colias hyale Linnaeus 1758 and named it alfacariensis. His type-material came from the mountains Sierra de la Yedra (ca. 1800 m) just north of the village Alfacar situated north of Granada, in southern Spain (i.e. Andalusia); he called this mountain range incorrectly 'Sierra de Alfacar' after the above mentioned village which he used as his base and this name became subsequently very widespread in entomological literature, particularly in the German language. The taxonomic category 'aberration' has been used either for some kind of individual form (s.l.) or for various extreme forms ranging often as far as pathologial and teratological individuals. "Aberration" is not among the taxonomic categories recognized by the ICZN. The rank of any aberration is therefore to be interpreted as infrasubspecific and, consequently, the names originally proposed for aberrations are unavailable. Should a name originally proposed for an aberration, or any other infrasubspecific category, be elevated by one of the subsequent authors to the speciesgroup rank (i.e. the species or the subspecies), it takes the date and authorship of its elevation (cf. Code, Art 10b) and its previous infrasubspecific application remains irrelevant and immaterial. To avoid any subsequent confusion (cf. Reissinger, 1971) it should be pointed out here that Ribbe (1905) in the same paper distinguished clearly between infrasubspecific names for individual form (i.e. aberrations) and available names interpreted now as of subspecies-rank, which he in accordance with the predominating custom of the period called "varietas": Satyrus actaea nevadensis Ribbe 1905 and Chrysephanus [sic] gordius granadensis Ribbe 1905 were both originally designated as "varlietasl."

Although the interpretation of the rank and status of the species-group and lower category names treated in the works of Seitz (1906-09, 1929-32) often presents considerable difficulties owing to ambiguity, it may be noted that Roeber (1907) retained unequivocally the rank of aberration for the taxon: "Ribbe found in Sierra d'Alfacar [sic] (Andalusia) an aberration which he calls alfacariensis:  $\sigma$  lighter yellow, the underside of the hindwing being more greyish yellow,  $\varphi$  above greenish white, similar to edusa ab. helice but with smaller black markings, the underside also being very similar to that of helice." (Quotation cited here is taken from the English edition of the book.)

Verity (1905-11) described a "race" of Colias hyale hyale Linnaeus, 1758 from southern Spain (i.e. "Andalusia") and named it australis. The original description was given on page 347, the full original combination on page XXXV of the same publication, and both were published at the same time (Verity, 1914); the necessity to consult the systematic index to establish the original combination and rank of all taxa named in Verity's

work cited above is given elsewhere (Kudrna, 1983, in print). Verity (1905-11) also defined the "race" as a infrasubspecific category, i.e. below the subspecies-rank, and the quadrinominal original combination *Colias hyale hyale australis* makes all abundantly clear. It may be noted that also races of monotypic species remain infrasubspecific and their names unavailable.

Verity (1916) described a seasonal form of *Colias hyale* (treated this time as a monotypic species) characteristic of the summer generation of the populations inhabiting southern Europe and named it *calida*; at the same time he designated syntypes (1  $\mathcal{O}$ , 1  $\mathcal{O}$ ) from Toscana (C. Italy). Names proposed for seasonal forms are always treated as unavailable names as they are excluded from the Code; they are infrasubspecific names as they apply only to a part of the population(s) of the species, being exclusive of a certain season of the year. It should be mentioned here that also names applied to a selected population(s) as the whole cannot be treated as species-group names (cf. Code, draft, 3rd edition).

Verity & Querci (1923-24) used the name calida for the southern European race of Colias hyale characterized by the presence of the seasonal form calida among the summer generation(s); the paper was serialized and the page concerned was published in 1923. Verity & Querci (1923-24) provided no description of the race calida, however, a bibliographical reference is given to the original description of the seasonal form of the same name. A trinominal combination, Colias hyale calida, seems implied. The race calida includes three seasonal forms: vernalis Verity 1908 in the first generation, calida in the second and third generation and "extraord. gen. hyale, L." in the fourth generation. Verity's taxonomic category "race" has given much cause for concern owing to its ambiguity: it was—and still often is—quite thoughtlessly interpreted as an equivalent of the subspecies. The names originally proposed by Verity for races have therefore been usually treated as if they were available names of subspecies-rank as from the date of their first publication (cf. Cockayne, 1952). Verity made it abundantly clear on several occasions that his "race" had little, if anything, in common with the subspecies (Verity, 1905-11, 1912, 1929, 1940); he more or less replaced the subspecies with the "exerge" (Verity, 1925-26, 1929) in all but his early publications (e.g. Verity, 1905-11, also Turati & Verity, 1911, 1912) and placed the race one rank below it, i.e. as an infrasubspecific and consequently unavailable name; this is true even about all monotypic species where the race-name comes placed third in the implied trinominal original combination (Kudrna, 1983). The significance of the intentions of the original author has not been adequately appreciated in the present Code, but this has already been corrected by ICZN (cf. Code, draft, 3rd edition). Verity's "exerge" (i.e. subspecies) was determined by its hereditary characters (i.e. genetically fixed), his "race" was determined by its somatic characters (i.e. phenotypic) caused directly by environmental pressures. This means that

the "race" differed from the "exerge" (i.e. the higher category) in its phenotypic features while their genetic characters remained identical. The race was often denoted by the name of a form thought to be predominant or characteristic (though not necessarily exclusive) of it, or of one of its distinct broods in case of polyvoltine species. Such is the case of the name calida used for a seasonal form and applied by Verity & Querci (1923-24) to the race characterized by the presence, or predominance, of that seasonal form in its summer broad(s). The race does not exclude examples of other conspecific forms from its populations (i.e. so called "mixed" races of Verity), the "exerge" (i.e. subspecies) does precisely the opposite, it being exclusive to a definite geographical area; only where two such "exerges" of the same species meet they form a "contact zone" and can interbreed. The race has no definite range. In case of all monotypic species, the genetic characters are specific, the phenotypic features "racial." Before his indirect replacement of subspecies by the new fanciful term "exerge" Verity (1920: 146 in 1919-22) stated: "the term 'subspecies' I should restrict to particular groups of races which only just fall short of the definite group we call 'species'."

Bollow (1930) made the following interpretation of the names calida and australis: "For the very fine and large summer generation of southern Europe Verity chooses as typical representative the hyale flying in Tuscany and names it calida" and "Further large brightly coloured  $\sigma \sigma$  and for a great part also similarly coloured  $\rho$  are shown by the race australis Vrty. from Andalusia. The black markings are often reduced." (Quotation from the English edition of the work.) The infrasubspecific status was retained.

Berger (1945) was first to recognize that *Colias hyale* consisted of two distinct species the adults of which differed only slightly but which had very distinct early stages, particularly the larvae, and one of them was a monophag feeding on *Hippocrepis comosa*. In his preliminary communication Berger (1945) cautiously avoided to propose a new name for the "new species" and called it simply after its foodplant to distinguish it for the oligophagous *Colias hyale*; he provided no description but suggested its identity with *Colias alfacariensis* of Ribbe (1905).

Berger (1948) published another preliminary paper on the two *Colias*-species which contained a brief but adequate description of adults and the early stages of the "new species", with notes on its biology and distribution chiefly in England; he also identified it as *Colias alfacariensis*. He elevated to the species-rank the aberration *alfacariensis* and, erroneously, retained the authorship and date of publication as: Ribbe 1905, Berger (1948) was apparently unaware of the consequences of the elevation of an unavailable name to the rank of species-group, i.e. that he, not Ribbe, became the author of the name, and that also the date of publication changed accordingly: *Colias alfacariensis* Berger 1948. In the circumstances, he

gave no information regarding the type-material (i.e. syntypes) of the new species and made no statement with regard to the type-locality; nonetheless, as he reported in his paper specifically *alfacariensis* from England, he used and listed English specimens when writing up his description of the species. It is important to state here that Berger's (1948) paper containing the original description of *alfacariensis* was published in August 1948.

A little earlier Berger & Fontaine (1947-48) started to publish a more detailed paper on *Colias alfacariensis* and dealt particularly with the biology and the early stages of both closely related species. The paper was serialized and the name *alfacariensis* was applied to the earlier published description, including also a detailed comparative study of adults, as late as in the last installment which appeared in December 1948. Berger & Fontaine (1947-48) attributed the authorship again to Ribbe 1905; they were apparently both unaware of the nomenclatorial consequences of their action. Also the second description satisfied the Code.

Hemming & Berger (1950) discussed the nomenclature of the new Colias and correctly observed that the name Colias alfacariensis became first available under the Code in 1948 and the author of that name was Berger. However, they were in error as they placed Colias alfacariensis Berger 1948 in synonymy and replaced it with Colias australis, the authorship and date of publication they gave to Verity 1911. This replacement was apparently suggested by F. Hemming who must have overlooked both the original combination stated by Verity (1905-11) and his definition of the race, either of which were alone adequate to show the infrasubspecific nature and the subsequent unavailability of the name australis. In fact, Hemming & Berger (1950) were the first authors to apply the name australis to the species identical with Colias alfacariensis Berger 1948.

Cockayne (1952) rejected both previously used names, i.e. Colias alfacariensis (regardless of authorship) and Colias australis Verity 1911 and pointed out that the oldest name for the species was calida Verity, with the date of publication 1923 when this was utilized for a race. He failed to observe that the authors of the paper were Verity & Querci and the infrasubspecific nature of the race in Verity's works. Cockayne's (1952) conclusions received little support and attention of subsequent authors, though the name calida was occasionally used chiefly for the "subspecies" of australis inhabiting central Europe, that is quite contradictory to both its original description and the type-locality given by Verity (1916).

Following the conclusions of Hemming & Berger (1950) the name *Colias australis* Verity 1911 became generally accepted by most of subsequent authors. There appeared a distinct need to provide an objective definition of the species by selection and designation of the name-bearing type. Riley (1954) located in the British Museum (Natural History) the rest of the type series that served Verity (1905-11) for the description of *Colias hyale hyale australis* Verity 1911 at his brief visit to the Museum while in London, after

only perfunctory examination of the unknown number of specimens. Riley (1954) pointed out the somewhat uncertain origin of the types and selected the lectotype (male). Warren (1954) aware of small differences usually present in male genitalia of the two species examined the genitalia of the lectotype; he pointed out that the selection of the specimen was unfortunate, if not questionable, as its genitalia were somewhat "transitional." There is no more need for this lectotype, perhaps a lucky solution in the circumstances.

Reissinger (1971) discussed the nomenclature of the species at considerable length and concluded that it should be named *Colias alfacariensis* Ribe 1905. His argument was based chiefly on facts irrelevant and/or immaterial from the nomenclatorial point of view and indicated his relative unawareness of both the principles of systematic zoology and the rules set out by the ICZN in the Code. Part of Reissinger's (1971) argument consists of misinterpretation of the known facts, such as the distinction Ribbe (1905) made between individual forms ("aberratio") and subspecies ("varietas").

The above perspective completes a taxonomic history full of errors which resulted in part from some unfortunate oversights of otherwise acknowledged entomologists. It is to be hoped that the name *Colias alfacariensis* Berger 1948 will soon replace the invalid names discussed here. It would seem most opportune to conclude this paper with the designation of the name-bearing type, i.e. the lectotype, of this species from the material that served Berger (1948) for his description. This would be best done in cooperation with the author himself, L. A. Berger. Unfortunately, all my earlier attempts to communicate with him failed to produce an answer. Should he decide to designate the lectotype from his syntypes, the selection of the right specimens is of utmost importance. It would seem that southern England should be the type-locality of *Colias alfacariensis* for the time being, to be later restricted according to lectotype (to be designated).

It may be useful to summarize here the original combinations of both infrasubspecific and available names cited in this paper:

- A) Index of unavailable (infrasubspecific) names: Colias hyale alfacariensis Ribbe 1905 Colias hyale hyale australis Verity 1911 Colias hyale calida Verity 1916
- B) List of available names for species (synonymy):

  Colias alfacariensis Berger 1948 (nec Ribbe 1905)

  Colias australis Hemming & Berger 1950 (nec Verity 1911)

  Colias calida Cockayne 1952 (nec Verity 1923)

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# Some Little-Known U. S. Publications on Lepidoptera I<sup>1</sup>

Cyril F. dos Passos

Research Associate, Department of Entomology, American Museum of Natural History, New York, New York 10024

Abstract. A confusing history is reviewed, namely, that of the bulletins put out by the Boston Entomological Society under two titles, viz, "The Lepidopterist" (1916-17) and "Lepidoptera" (1918-21). An additional publication, by Samuel E. Cassino, which also went by the name "The Lepidopterist" (1918-31) is given due notice. All known numbers of these serials are listed, with dates of issue, pagination and inclusions.

## Foreword

This is the first of a two-part series, drawing upon manuscripts which have been entrusted to me by Dr. dos Passos since failing health has curtailed his research activities. Among his unpublished papers are dissertations on a number of obscure publications devoted to Lepidoptera. The serials described hereinafter are probably the most important of those short-lived bulletins and occasional papers. Others will be made the subject of a later article. The collations are verbatim from the dos Passos manuscripts, as is also the historical account aside from some minor emendation and rearrangement. An included letter from John D. Sherman, the bookseller, has been omitted since its gist was to corroborate the sequence of plate figures as listed. The latter topic is touched upon further in the text. Aside from a trifle of editing, and preparation of the abstracts, I have merely dipped into the wealth of bibliographic data and notes which Dr. dos Passos had assembled. I have little claim to co-authorship.

#### **Historical Summary**

The early 20th century was a period of great activity among amateur lepidopterists in the United States. Holland's Butterfly Book had been published in 1898 and his Moth Book appeared in 1903. They were most successful and gave great encouragement to amateur collectors besides enlisting many new members into the hobby. This from time to time resulted in the formation of clubs and societies and the publication of amateur journals. Outstanding among these was the Boston Entomological Club which flourished during this era and sponsored a bulletin which, along with an offshoot therefrom, is described herein. It should be noted that this club was separate from the Cambridge Entomological Club which published Psyche during the same period.

As "Official Bulletin of the Boston Entomological Club" (thusly proclaimed on

Abstract and foreword by L. P. Grey, Rte. 1, Box 216, Lincoln, Maine 04457

the masthead of each issue) numbers 1-10 of volume 1 were published under the name "The Lepidopterist", with Rudolph C. B. Bartsch designated as editor. So far, so good. But then dissention appears to have seized upon the club. Bartsch resigned as editor (under pressure, one gathers). Beginning with volume 1, number 11, the masthead cites Samuel E. Cassino, publisher, continued through numbers 12 and 13 which concluded the volume. The changeover was explained (rather lamely) as being due in part to trouble with postal service in the Boston area and Cassino's ability to make deliveries more promptly from his printing establishment in Salem.

One does not have to read altogether between the lines to learn of disagreements at this time; some of them were aired publicly, in the bulletins. In return for his services as publisher, Cassino began to demand full editorial powers. These, the club refused to grant, whereupon Cassino retaliated by *copyrighting* the title and continuing with volume 2, number 1, of "The Lepidopterist". This action was promptly disclaimed, and so henceforth Cassino's volume 2, number 2, through to the final issue, volume 5, number 3, are no longer mastheaded as "Official" and are to be regarded as a private enterprise sponsored and conducted by Cassino (although still being issued under the original title, "The Lepidopterist").

Meanwhile, back at the Club, and beginning likewise as volume 2, number 1, the "Official Bulletin" was continued under a new title, viz, "Lepidoptera". The editor was Nathaniel Stowers, with Robert Swift as scientific editor and E. F. Knight as advertising manager. This publication was more regular than Cassino's but did not last so long. Both, however, published about the same number of issues. For collation purposes the issues sponsored officially by the Boston Entomological Club are given in order, under the two titles but treated as one serial, while Cassino's schismatic bulletin is collated separately.

Most of the needed data were available in the dos Passos library (which has been donated to Wittenburg University). Photostats of two lacking numbers were supplied by Miss Nina Root, of the American Museum of Natural History library; she aided with other services also. Mr. John D. Sherman assisted, sharing his formidable knowledge in this field, as did some other colleagues who were queried in an effort to make reasonably certain that the collations are complete and accurate.

There remains a bit of a question if all of the plates are accounted for properly, since these were not always numbered or even bound into the individual numbers. In fact, the plates sometimes were issued separately and after the number in which they should have appeared had been published. This, if nothing more, may have elicited Sherman's expressed judgment that both publications were "criminal"!

Regardless of this and despite whatever minor flaws in collations may yet be discovered, the following resume should be of abiding utility for a variety of reasons. These serials are replete with original descriptions of butterflies and especially of moths (rich in Catocala and Geometridae). Most of the important lepidopterists of the period were contributors, e.g., John A. Comstock, William Beutenmueller, Samuel E. Cassino, L. W. Swett and many others whose proposed taxa must be dated correctly. Apparently there is no flaw in validity of publication, either with the "Official" bulletins or with Cassino's separate project, that is, with reference to Article 8 of the International Code. Both papers were printed and distributed as required, mailed to subscribers as well as being advertised for sale separately—starting out at 35¢ annually or 4¢ per issue!

## The Lepidopterist 1916-17

(Rudolph C. B. Bartsch, Editor)

		Pages		
(1)	Nov. 15, 1916	1-8	Pl. [I]	
(2)	Dec. 15, 1916	9-18	Pl. II colored	
(3)	Jan. 15, 1917	19-36	Pl. III colored	
(4)	Feb. 15, 1917	27-34		
(5)	Mar. 15, 1917	35-42		
(6)	May 1, 1917	43-50		
(7)	May 15, 1917	51-58		
(8)	June 1, 1917	59-66	Pl. IV	
(9)	June 15, 1917	67-74	Pl. V	
(10)	July 15, 1917	75-82	Pl. VI	
	(Samuel	E. Cassino	o, Publisher)	
(11)	Aug. 15, 1917	83-90	Pl. VII	
(12)	Nov. 15, 1917	91-98		
(13)	Dec. 15, 1917	99-106	Pl. [VIII] colored	Index, 4
			pp.	
	(2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12)	(2) Dec. 15, 1916 (3) Jan. 15, 1917 (4) Feb. 15, 1917 (5) Mar. 15, 1917 (6) May 1, 1917 (7) May 15, 1917 (8) June 1, 1917 (9) June 15, 1917 (10) July 15, 1917  (Samuel (11) Aug. 15, 1917 (12) Nov. 15, 1917	(2) Dec. 15, 1916 9-18 (3) Jan. 15, 1917 19-36 (4) Feb. 15, 1917 27-34 (5) Mar. 15, 1917 35-42 (6) May 1, 1917 43-50 (7) May 15, 1917 51-58 (8) June 1, 1917 59-66 (9) June 15, 1917 67-74 (10) July 15, 1917 75-82  (Samuel E. Cassino (11) Aug. 15, 1917 83-90 (12) Nov. 15, 1917 91-98	(1) Nov. 15, 1916 1-8 Pl. [I] (2) Dec. 15, 1916 9-18 Pl. II colored (3) Jan. 15, 1917 19-36 Pl. III colored (4) Feb. 15, 1917 27-34 (5) Mar. 15, 1917 35-42 (6) May 1, 1917 43-50 (7) May 15, 1917 51-58 (8) June 1, 1917 59-66 Pl. IV (9) June 15, 1917 67-74 Pl. V (10) July 15, 1917 75-82 Pl. VI  (Samuel E. Cassino, Publisher) (11) Aug. 15, 1917 83-90 Pl. VII (12) Nov. 15, 1917 91-98 (13) Dec. 15, 1917 99-106 Pl. [VIII] colored

## Lepidoptera 1918-21

(Robert Swift and Nathaniel Stowers, Editors)

			Pages	
Vol. II	(1)	Jan. 15, 1918	107-114	[sic] [1-8]
Vol. II	(2)	Feb. 15, 1918	9-16	
Vol. II	(3)	Mar. 15, 1918	17-24	
Vol. II	(4)	Apr. 15, 1918	25-32	
Vol. II	(5)	May 15, 1918	33-40	Pl. I
Vol. II	(6)	June 15, 1918	41-48	
Vol. II	(7)	July 15, 1918	49-56	
Vol. II	(8)	Aug. 15, 1918	57-64	
Vol. II	(9)	Sept. 15, 1918	65-72	
Vol. II	(10)	Oct. 15, 1918	73-80	
Vol. II	(11)	Nov. 15, 1918	81-88	
Vol. II	(12)	Dec. 15, 1918	89-96	Index 4 pp.
Vol. III	(1)	Jan. 15, 1919	1-8	
Vol. III	(2)	Feb. 15, 1919	9-16	Directory 2 pp.
Vol. III	(3)	Mar. 15, 1919	17-24	
Vol. III	(4)	Apr. 15, 1919	25-32	
Vol. III	(5)	May 15, 1919	33-40	Directory 3 pp.
Vol. III	(6)	June 15, 1919	41-48	Pl. I
Vol. III	(7)	July 15, 1919	49-56	Pl. II
Vol. III	(8)	Aug. 15, 1919	57-64	Pl. III
Vol. III	(9)	Sept. 15, 1919	65-72	Pl. IV
Vol. III	(10)	Oct. 15, 1919	73-80	
Vol. III	(11)	Nov. 15, 1919	81-88	Pl. V
Vol. III	(12)	Dec. 15, 1919	89-96	Index 4 pp.

Vol. IV	(1)	Jan. 1920	1-8	Pl. I cover
Vol. IV	(2)	Feb. 1920	9-16	Pl. II cover
Vol. IV	(3)	Mar. 1920	17-24	cover
Vol. IV	(4)	Apr. 1920	25-32	cover
Vol. IV	(5)	May 1920	33-40	Pl. III, IV cover
Vol. IV	(6)	June 1920	41-48	Pl. V cover
Vol. IV	(7)	July 1920	49-56	cover
Vol. IV	(8)	Aug. 1920	57-64	cover
Vol. IV	(9)	Sept. 1920	65-72	cover
Vol. IV	(10)	Oct. 1920	73-80	cover
Vol. IV	(11)	Nov. 1920	81-88	cover
Vol. IV	(12)	Dec. 1920	89-96	Index, 3 pp. cover
Vol. V	(1)	March 1921	1-12	
Vol. V	(2)	Sept. 1921	13-24	

Information supplied by Dr. A. E. Brower, of Augusta, Maine, indicates that at the Sixth Annual Meeting of the Boston Entomological Club the following arrangement was made concerning *Lepidoptera*:

"The Magazine Lepidoptera is discontinued. Henceforth the Official Bulletin of the Boston Entomological Club will be "The Clansman" which is published every month by Mr. Harry G. Haskell, of Hyde Park, Mass."

The last entry Dr. Brower found in *The Clansman* concerning the activities of the Boston Entomological Club was a few miscellaneous notes on insect collectors in volume 1, numbers 5-6, July-August 1922, on page one. Sic Transit...

## The Lepidopterist 1918-31

(Samuel E. Cassino, Publisher)

			Pages	
Vol. II	(1)	Jan. 15, 1918	1-8	Pl. [1] colored
Vol. II	(2)	Feb. 25, 1918	9-16	Pl. 3, 4 Pl. [2] colored
Vol. II	(3)	Mar. 25, 1918	17 - 24	
Vol. II	(4)	Apr. 25, 1918	25-32	Pl. "6" [5] colored
Vol. II	(5)	May 25, 1918	33-40	Pl. 6 [sic]
Vol. II	(6)	June 25, 1918	41-48	Pl. 7, 8 colored
Vol. II	(7)	July 25, 1918	49-56	Pl. 9
Vol. II	(8)	Aug. 25, 1918	57-64	
Vol. II	(9 & 10	O)Oct. 25, 1918	65-80	Pl. [10] [11]
Vol. II	(11 &	Dec. 25, 1918	81-96	
	12)			
Vol. III	(1)	Mar. 15, 1919	97-104	
Vol. III	(2)	July 15, 1919	105-112	
Vol. III	(3)	Jan. 1, 1920	113-120	
Vol. III	(4 & 5	) Feb. 16, 1920	121 - 136	
Vol. III	(6 & 7	) Feb. 15, 1922	137-150	
Vol. III	(8)	Mar. 15, 1922	151 - 158	
Vol. III	(9)	Apr. 15, 1922	159-166	Pl. [12]
Vol. III	(10)	Aug. 15, 1922	167-174	
Vol. III	(11)	Sept. 15, 1922	175 - 182	

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Vol. III
                  Nov. 1, 1922
          (12)
                                    183-190
Vol. IV
          (1)
                  Apr. 1, 1923
                                    1-8
Vol. IV
          (2)
                  June 1, 1923
                                    9 - 16
Vol. IV
                  Dec. 25, 1923
          (3)
                                    17-24
Vol. IV
          (4)
                  Jan. 1, 1924
                                    25 - 32
Vol. IV
          (5)
                  May 10, 1925
                                    33-40
Vol. IV
          (6 & 7) June 10, 1925
                                    41-56
Vol. IV
          (8 & 9) Feb. 25, 1927
                                    57-72
Vol. IV
          (10)
                  Apr. 15, 1927
                                    73 - 80
Vol. IV
          (11)
                  June 1, 1927
                                    81-88
Vol. IV
          (12)
                  Mar. 15, 1928
                                    89-96
Vol. V
          (1)
                  Aug. 1, 1928
                                    1-8
Vol. V
          (2)
                  May 1, 1931
                                    9-16
                                               [corrected in ink]
                  June 15, 1931
Vol. V
          (3)
                                    17 - 24
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Commencing with volume 2, number 5, Cassino, together with Louis W. Swift, were described as editors, but with volume 3, number 11, "Editors" was dropped and thenceforth Cassino was designated as publisher.

There are many line drawings throughout this journal. So far as is known, no indexes to the volumes were published and no covers have been seen.

The letter previously mentioned, from Sherman, the book dealer, indicated that even in 1939, when the Boston Entomological Club publications and Cassino's bulletin both had not been long out of existence, they were rare items and hard to come by. The set in the American Museum of Natural History library is believed to be complete for both.

# Some Little-Known U. S. Publications on Lepidoptera II<sup>1</sup>

Cyril F. dos Passos

Research Associate, Department of Entomology, American Museum of Natural History, New York, New York 10024

Abstract. Notes and collations are given for the following publications which are of historical interest to lepidopterists: The Sierra Club Bulletin 1913; The Butterfly Farmer 1913-14; Lorquinia 1916-19; Southwest Science Bulletin 1920; Butterfly Park Nature Club News 1929-31; The Lepidopterists' News 1933 (not to be confused with any publication of the present Lepidopterists' Society); Hobbies—The Magazine for Collectors 1936, also The Entomologists' Exchange Association 1936, also The Entomologists' Exchange News 1937-42; The Butterfly Club 1946-47; Club Notes, Moth and Butterfly Club [?1947]-53, also Notes on Moths and Butterflies 1953-55.

### Sierra Club Bulletin 1913

While decidedly not a poorly known publication, it does not seem to be widely known that volume 9, number 2 of the Sierra Club Bulletin contains important papers on Lepidoptera by Vernon L. Kellogg and Fordyce Grinnell, Jr. This number of the Bulletin is publication no. 48, June 1913, pp. 81-128. It deserves a place in entomological libraries.

### The Butterfly Farmer 1913-14

The Butterfly Farmer, a monthly magazine for amateur entomologists, was published by Miss Ximena McGlashan, of Truckee, California, commencing with the September number in 1913 and ending with the August number in 1914. This publication included, as a leading feature in each number, parts of a comprehensive correspondence course in entomology conducted under the auspices of The Agassiz Association, and also included much current news in the entomological world, especially that part thereof devoted to butterflies and moths. It was copyrighted by Miss McGlashan. It may be collated as follows:

			Pages	
Vol. 1	(1)	Sept. 1913	1-16	
Vol. 1	(2)	Oct. 1913	17-32	
Vol. 1	(3)	Nov. 1913	33-48	
Vol. 1	(4)	Dec. 1913	49-64	
Vol. 1	(5)	Jan. 1914	65-80	
Vol. 1	(6)	Feb. 1914	81-96	
Vol. 1	(7)	Mar. 1914	97-112	
Vol. 1	(8)	April 1914	113-132	
Vol. 1	(9)	May 1914	133-148	
Vol. 1	(10)	June 1914	149-168	
Vol. 1	(11)	July 1914	169-184	
Vol. 1	(12)	Aug. 1914	185-208	including index

This was a useful little publication and still is of interest, particularly for the biographies and pictures of old-time entomologists. With the second number, C. F. McGlashan, the father of Ximena, was listed on the cover as associate editor and business manager, and on page 67 their picture, taken together, was given. Always on the cover the picture of Miss McGlashan appeared. The subscription price was \$5.00 per year, single copies 50¢.

In addition to *The Butterfly Farmer*, Miss McGlashan published two large foodplant lists for the benefit of her students, one based on Holland's *Butterfly Book* and the other on the same author's *Moth Book*. The foodplant list for butterflies was Circular No. 6, March 1913, and measured approximately 0.48 m by 0.70 m. The foodplant list for moths was Circular No. 8, May 1913, measuring approximately 0.48m by 0.78 m. The other circulars have not been seen.

### Lorquinia 1916-19

Lorquinia was published by the Lorquin Natural History Club, of Los Angeles, California, between August 1916 and January 1919. Its officers when the publication commenced were: Luther Little, President; Rutherford D. Moore, Vice-President; F. Grinnell, Jr., Secretary; and E. P. Chace, Treasurer. The editor

was Paul D. R. Ruthling. He was succeeded by George L. Moxley. At that time the Club had 20 active, 3 honorary and 10 charter members., *Lorquinia* published many botanical and entomological papers and notes. It collates as follows:

			Pages	
Vol. 1	(1)	Aug. 1916	1-8	
Vol. 1	(2)	Sept. 1916	9-11	[+ "4" (12), "5" (13), 14, 15, "18" (16)]
Vol. 1	(3)	Oct. 1916	17-24	
Vol. 1	(4)	Nov. 1916	25-32	
Vol. 1	(5)	Dec. 1916	33-40	
Vol. 1	(6)	Jan. 1917	41-48	
Vol. 1	(7)	Feb. 1917	49-56	
Vol. 1	(8)	Mar. 1917	57-64	
Vol. 1	(9)	Apr. 1917	65-72	
Vol. 1	(10)	May 1917	73-80	
Vol. 1	(11)	June 1917	81-88	
Vol. 1	(12)	July 1917	89-96	
Vol. 2	(1)	Aug. 1917	1-8	
Vol. 1	(2)	Sept. 1917	9-16	
Vol. 2	(3)	Oct. 1917	17-24	
Vol. 2	(4)	Nov. 1917	25-32	
Vol. 2	(5)	Dec. 1917	33-40	
Vol. 2	(6)	Jan. 1919	1-12	

The Lorquin Natural History Club was affiliated with the Southwest Museum and quarterly issues of Lorquinia were contemplated. A set of these papers obtained from the library of Fordyce Grinnell, Jr., has a note in pencil on the first page of the January 1919 issue, viz, "Last issue." There is no index to any volume nor have any covers been seen. Mrs. Dorothy E. Martin, former Librarian of the Los Angeles County Museum, has confirmed also that volume 2, number 6 was the last number issued. The organization name was changed to the Lorquin Entomological Society, which is still quite active in Los Angeles with over 100 members. The society has published a newsletter (10 issues per year, unnumbered) since about 1955.

### Southwest Science Bulletin 1920

The Southwest Science Bulletin was published by the Southwest Museum under the supervision of the Council of the Southwest Science Association, Marmon Way and Avenue 46, Los Angeles, California. Only one copy has been seen, which was issued May 5, 1920 and consists of 32 pages, one colored plate and four black-and-white plates. It contains articles on butterflies and moths. Nothing further has been learned about this publication. Mrs. Martin kindly confirmed the fact that only one number ever was issued.

### **Butterfly Park Nature Club News 1929-31**

Butterfly Park Nature Club News commenced publication in March 1929. It was printed at Roscoe, California. Albert Carter appears to have been the leading spirit. He had the publication copyrighted. Mr. William D. Field, formerly of the National Museum of Natural History, supplied the following collation:

			Pages
Vol. 1	(1)	Mar. 1929	4
Vol. 1	(2)	Apr. 1929	4
Vol. 1	(3)	May 1929	4
Vol. 1	(4)	June 1929	4
Vol. 1	(5)	July 1929	4
Vol. 1	(6)	Aug. 1929	4
Vol. 1	(7)	Sept. 1929	4
Vol. 1	(8)	Oct. 1929	4
Vol. 1	(9-10)	NovDec. 1929	4
Vol. 1	(11-12)	JanFeb. 1930	4
Vol. 2	(1-2)	MarApr. 1930	4
Vol. 2	(3-4)	May-June 1930	4
Vol. 2	(5)	Oct. 1930	4
Vol. 3	(6)	Jan. 1931	8
Vol. 3	(7)	Apr. 1931	4
Vol. 3	(8)	July 1931	4
Vol. 4	(1)	Jan. 1932	8

Whether anything further was published has not been ascertained.

### The Lepidopterists' News 1933

This publication is not to be confused with any publication of the present Lepidopterists' Society, with which it had nothing whatsoever to do.

The Lepidopterists' News was published by the Florida Society of Lepidopterists of the Florida Society of Natural History. Only two numbers have been seen, both mimeographed, edited by Mrs. Elizabeth O. Groves and J. Harold Matteson, as follows:

			Pages
Vol. 1	(1)	June 1932	8
Vol. 1	(2)	Dec. 8, 1933	6

Number 1 was letterhead size, number 2 was octavo.

### Hobbies-The Magazine for Collectors 1936

In July 1936 Hobbies ran a department entitled "Natural History" in which Frank Clay Cross published the "Entomologists' Exchange Association". This July issue is the only one which has been inspected; it was the 9th number and 41st year of that magazine. It catered to many tastes and in 1936 it ran several articles on Lepidoptera written by Cross. These were:

March 1936	A Hobby on Wings. Vol. 41, no. 1, pp. 112-113, 119
April 1936	Reminiscences of a Butterfly Bungler. Vol. 41, no. 2, pp. 112-113
July 1936	Entomologists' Exchange Association. Vol. 41, no. 5, pp. 112-
	113

Also in the March number of *Hobbies*, Cross announced (p. 113) organization of the Entomologists' Exchange Association, which commenced publication that month.

### The Entomologists' Exchange Association 1936 The Entomologists' Exchange News 1937-1942

Information concerning these publications has been supplied by Mr. William D. Field, formerly of the National Museum of Natural History. it appears that Frank C. Cross, then of Denver, Colorado, initiated a paper the first numbers of which were typewritten, viz:

			Pa	ages
[Vol. 1]	[1]	circa March 1936	1	
[Vol. 1]	[2]	circa May 1936	1	2 p. list tentative members
[Vol. 1]	3	circa June 1936	1	Bulletin added to title

The second publication was mimeographed and the name was changed to "The Entomologists' Exchange News". The first two numbers have not been seen.

Emomoro	gioto Elacitani	seriews . The mist two	numbers i
			Pages
Vol. 2	(3)	July 1, 1937	2
Vol. 2	(4)	Aug. 1, 1937	2
Vol. 2	(5)	Sept. 1, 1937	6
Vol. 2	(6)	Oct. 1, 1937	3
Vol. 2	(7)	Nov. 1, 1937	2
Vol. 2	(8)	Dec. 1, 1937	4
Vol. 2	(9)	Jan. 1, 1938	3
Vol. 2	(10)	Feb. 1, 1938	2
Vol. 2	(11)	March 1, 1938	2
Vol. 2	(12)	April 1, 1938	2
Vol. 3	(1)	May 1, 1938	3
Vol. 3	(2-4)	June-Aug. 1938	3
Vol. 3	(5)	Sept. 30, 1938	3
Vol. 3	(6)	Oct. 30, 1938	3
Vol. 3	(7)	Nov. 30, 1938	7
Vol. 4	(1)	Jan. 5, 1939	3
Vol. 4	(2)	Feb. 4, 1939	6
Vol. 4	(3-4**)	April 10, 1939	2
Vol. 4	(5 <b>*</b> )	May 18, 1939	5
Vol. 4*	(6-7)	July 25, 1939	5
Vol. 4*	(8)	Sept. 5, 1939	5
Vol. 4*	(9-10)	Nov. 20, 1939	5
Vol. 5*	(1)	Jan. 30, 1940	5
Vol. 5*	(2-3)	March 5, 1940	6
Vol. 5	(4-6)	June 5, 1940	8
Vol. 5	(7-8)	Aug. 5, 1940	6
Vol. 5	(9-11)	Nov. 27, 1940	2
Vol. 6	(1-2)	Feb. 15, 1941	4
Vol. 6	(3)	March 25, 1941	5
Vol. 6	(4)	April 17, 1941	6
Vol. 6	(5-8)	Aug. 1941	3
Vol. 6	(9-10)	Oct. 1941	3
Vol. 7	(1)	Jan. 10, 1942	4

Vol. 7 (2) Feb. 13, 1942

Volume 7, number 2 is the last number seen. It is not known whether anything further was published.

\*Asterisks indicate errors in numbering issues, a plague of which infested these runs. To wit: for 1939: April 10, number "4 & 5" was 3-4 in proper sequence; May 18 was number 5, not "6". The July issue was correctly numbered but cited volume number incorrectly as "3", continued through the two issues following. In 1940, beginning volume 5 the first two issues were numbered "vol. 4". Finally, the June issue, 1940, got back on track as volume 5, numbers 4-6.

This paper started out and ended on letter-size sheets, with an interim of legalsize issues from volume 2, number 12 through volume 4, number 1.

#### Inclusions

Lists of members in volume 2, number 5; volume 4, number 2; volume 6, numbers 1-2 and 3 and 9-10. Volume 3, number 7 had a list of "species in the Cheyenne Mountain Museum". With volume 3, number 2-4 Robert Potts took over as editor. Volume 5, number 9-11 contains a statement that F. Martin Brown was editor before Potts. Brown appears also to have been treasurer, at least from volume 2, number 12 on. A field collecting form was included in volume 4, number "4 & 5" [3 & 4]. Beginning with the issue of July 25, 1939, the *News* was published by the Colorado Biological Survey and the Cheyenne Mountain Museum. A "preliminary list of the butterflies and skippers of Santa Clara and Santa Cruz" was featured in volume 6, number 4.

### The Butterfly Club 1946-1947

These were mimeographed letters, written and distributed by Mrs. Evelyn G. Williams on behalf of the Howell Mountain Butterfly Club, for a period of about one year, from her residence in Sanitarium, California. Acquisition of Xeroxed copies which were kindly provided by Mrs. Bernice Neimi, of Aberdeen, Washington, has made possible a collation, not given here in full because so easily summarized, viz: The issues ran in sequence, monthly, from volume 1, number 3, September 1946, through volume 1, number 11, July 1947. Then, volume 2, number 1, dated September 1947, which is the last number. These were all short papers (Nov.-March, 1 page; April-Sept., 2 pp). Numbers 1 and 2 of volume 1 have not been seen although doubtless they exist, as also the missing number 12. It is not known how many numbers, if any, were published after volume 2, number 1. Perhaps somebody knows and will enlighten us?

Mr. Dominick J. Pirone, of Yonkers, New York, called attention to this bulletin and suggested that Mrs. Neimi might have copies.

It appears that Mrs. Williams also wrote a booklet entitled "Starting Your Butterfly Collection" which she sold for 10¢ a copy, later increased to 25¢. This booklet has not been seen.

### Club Notes, Moth and Butterfly Club [?1947/1953] Notes on Moths and Butterflies 1953-1955

This serial was published by the Moth and Butterfly Club under slightly different titles. In 1953 James M. Unseld, Jr. was the editor. Publication apparently ceased in 1955.

No issues prior to January 1953, volume 7, number 1, have been located, so it is impossible to say when publication began. After writing to all of the Club members whose names could be ascertained, an answer finally came from Mr. Richard T. Arbogast, Savannah, Georgia, that he had volume 7 to 9 almost complete. Later, he kindly furnished Xeroxed copies of the numbers which were lacking in the dos Passos library, and also volunteered leads to run down in the effort to obtain volumes 1 to 6, which were pursued but unfortunately without success.

With the June 1953 issue, "Club" was dropped from the title, Unseld stepped down as editor and was succeeded by Clifford Verhoeff, of Bristol, Colorado. Unseld's predecessor, if any, is not known. Whether volume VIII, numbers 5 and 6 were issued also remains in question; they have not been seen.

Volumes 7 and 8 have been collated as follows:

			Pages
Vol. "VIII"	(1) [Vol. VII]	Jan. 1953	4
Vol. "VIII"	(2) [Vol. VII]	Feb. 1953	3
Vol. "VIII"	(3) [Vol. VII]	March 1953	3
Vol. "VIII"	(4) [Vol. VII]	April 1953	6
Vol. "VIII"	(5) [Vol. VII]	May 1953	3
Vol. VII	(6)	June 1953	2
Vol. VII	("6") [7]	July 1953	2
Vol. VII	(8)	Aug. 1953	2
Vol. VII	(9)	Sept. 1953	2
Vol. VII	(10)	Oct. 1953	3
Vol. VII	(11)	Nov. 1953	4
Vol. VII	(12)	Dec. 1953	3
Vol. VIII	(1)	JanFeb. 1954	5
Vol. VIII	(2)	March 1954	3
Vol. VIII	(3)	April 1954	3
Vol. VIII	(4)	June 1954	3
Vol. VIII	("7 & 8") [5 & 6]	July-Aug. 1954	4
Vol. VIII	("9 & 10") [7 & 8]	SeptOct. 1954	2
Vol. VIII	([11] & (12)	NovDec. 1954	2
Vol. VIII	(1 [& 2]) [Vol. IX?]	JanFeb. 1955	1
Vol. VIII	(3 & 4)	March-Apr. 1955	2

Inclusions: January 1953 list of 42 members; January-February 1954 list of 35 members.

A note regarding this Club occurs in the 1953 Annals of the Entomological Society of America (46: 220). It was by "M. T. J." [Maurice T. James, the managing editor] as follows: "According to James M. Unseld, Jr., Gravel Switch, Kentucky, the Moth and Butterfly Club is an organization open to anyone interested in the study of Lepidoptera. At present there are fifty-five members. Annual dues are \$1.50. The Club Notes are issued monthly in mimeographed form. Mr. Unseld is the editor. The April 1953 issue is indicated as Volume VIII, number 4."

Acknowledgments. Generous assistance was provided by many individuals in the course of assembling foregoing data. Special thanks go to Mrs. Dorothy E. Martin, former Librarian of the Los Angeles County Museum, and to Miss Nina Root, Librarian of The American Museum of Natural History. Mr. Richard T. Arbogast, of

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Savannah, Georgia, aided considerably as noted earlier. Inquiries made during preparation of the collations were sent to nearly 100 individuals, many of whom responded helpfully. Unfortunately, some sections are incomplete, but they would have been far more so without the cooperation of many individuals, especially Mr. William D. Field, of Washington, D. C.

Quite surely the present treatment could be made more definitive and it is to be hoped that further information, if available, will be published. It is especially desirable to consolidate the histories of earlier club and society bulletins now that a veritable spate of such have begun to come out in recent years.

#### Errata

In my article "Description and taxonomic implications of an unusual Arizona population of *Apodemia mormo* (Riodinidae)" (*J. Res. Lepid. 18*(3): 201-207), two errors have been noted which require correction:

p. 204: the plate has been printed backwards so that label information is transposed for the specimens at each end of a row.

p. 205, line 5: sympatric should read allopatric.

Gregory S. Forbes, Box 3AF, Dept. of Biology, New Mexico State University, Las Cruces, NM 88003

In the issue "A Revision of the American Genus Anisota" (J. Res. Lepid. 19(3)), three errors have been noted which require correction:

p. 133: Fifth instar: Body color blackish-brown (not beige-brown) as the figure also shows.

p. 134: Boisduval should be in brackets.

p. 175: Plate VII. 9. should read: A. pellucida x virginiensis.

# A New Species of *Adelpha* (Nymphalidae) from Parque Nacional Braulio Carrillo, Costa Rica

Philip J. DeVries

and

Isidro Chacon Gamboa

Department of Zoology, University of Texas, Austin, Texas 78712 and Museo Nacional, Apartado 749, San Jose, Costa Rica

**Abstract.** The new butterfly species *Adelpha stilesiana* (Nymphalidae) is described from Costa Rica. This new species apparently represents another Costa Rican butterfly endemic to the Carrillo Belt. A few rudimentary field observations are also presented.

In Costa Rica, there are 26 species in the genus Adelpha (Nymphalidae) that fall roughly into two groups; the typical white banded species, and a smaller group of species that are brown dorsally with a broad orange band across the forewings and without white on either wing. In this latter group there are four species recorded from Costa Rica: Adelpha melanthe Bates, A. zalmona sophax Godman & Salvin, A. boreas tizona Felder, and A. salmoneus salmonides Hall. The interested reader is referred to either Fruhstorfer (1910-1912) or Godman & Salvin (1879-1901) where these species are illustrated. During the course of a long term study on the butterfly fauna of Parque Nacional Braulio Carrillo, a fifth and undescribed species of the orange-banded group has come to our attention. This species is not found in any world museum studied by one of us (PJD), and it is quite distinct from its congeners. We here describe this new species of Adelpha and give some general notes on its distribution and behavior in the field.

### Adelpha stilesiana DeVries & Chacon new species

Male: Eyes. Sparsely hairy except for a dense paths of hairs on the dorsum of the eyes near the base of the antenae. Antennae. Dark brown and naked except for a small patch of white scales on the ventrum near the base.

FW upperside: Dark brown from base to distal end of cell; submarginal area with a wide orange-yellow band which has a somewhat jagged inner and outer margin; the band runs from costa at R<sub>1</sub>-R<sub>2</sub> and extends broadly to distal wing margin at M<sub>2</sub> to 2A. HW upperside: Dark brown as in the FW but bears a faint subcostal line of lighter brown. FW underside: Similar to A. salmoneus and A. zalmona but differing distinctly as follows: cell area greyish-violet bearing two wide rufous

bands, one in mid-cell, the other at the end of the cell; both bands are thinly bordered by dark brown; are distad of cell end washed with pale ochre, being brightest on distal margin between M2-2A; a series of six prominent whitish postmedial spots between veins R3-R4, R4-M1, M1-M2, M2-M3, M3-Cu1, and Cu1-Cu2; a series of small spots run distad to those just described but beginning in R5-M1, running posteriorly between all veins and terminating in a double spot in cell Cu2 near the tornus. HW underside: Similar to that of A. salmoneus but with a dingy violet overcast to the ground color; a dark brown postmedial line runs from the costal margin, inflating in the discal area, and terminating in the anal angle as a rufous patch; marginal lobes of wing with spots of ochre centered on veins M1, M2, Cu1, and Cu2; fringe dark brown.

Genitalia: See figure (3) for details.

Female: The solitary female is virtually identical in pattern to the male.

Length of FW: male: 32 mm; female: 34 mm.

Types: Holotype: male, Costa Rica, Provincia de San Jose, Parque Nacional Braulio Carrillo, Estacion La Montura, May 24, 1981, 1100 m altitude, leg. Ruben Canet M.. Paratype: female, Costa Rica, San Jose, Carrillo, La Montura, 1100 m, June 11, 1980, leg. F. G. Stiles. Both in the British Museum (Natural History).

**Diagnosis.** See figures 1 and 2 for details. This species can be distinguished from all other Costa Rican congeners by the wide orange forewing band that ends broadly along the distal margin. This character can be used to distinguish this species in the field.

Etymology: We name this species for F. Gary Stiles who, incredibly enough, let us talk him into carrying a butterfly net in addition to his bird collecting gear and who successfully mist-netted the first specimen.

#### Discussion

Adelpha stilesiana is known only from two specimens (the types) and collected in the same locality. This locality is part of the Carrillo Belt (see DeVries, 1980) which is known for its unusual faunal and floral characteristics. The Carrillo Belt harbors a number of endemic Costa Rican



Fig. 1. Dorsal aspect of holotype.

Fig. 2. Ventral aspect of holotype.

butterflies and is also the habitat where some South American species terminate their northern range (e. g. Morpho granadensis Felder, Heliconius eleuchia Hewitson, Eunica norica Hewitson, and Epiphile eriopis Hewitson). Due to the total absence of specimens of A. stilesiana in the British Museum (Natural History), Smithsonian Institution, Carnegie Museum, Allyn Museum of Entomology, and numerous private collections viewed by us, we suggest that it is a species endemic to the Carrillo Belt.

From our work in Parque Carrillo, we have observed a number of individuals of A. stilesiana from 1100 to 800 meters elevation. Individuals perch on foliage along the insides of ravines or in the forest canopy from 0800 to about 1100 hours. As most other Adelpha species in Costa Rica, individuals perch from 5 to 10 minutes at the same spot and make sorties out from the perch, returning repeatedly to the same spot. They then move to a different area that is usually 50 or more meters away.

On the wing, A. stilesiana looks very similar to A. salmoneus and A. zalmona sophax which also occur in the same habitat. Positive field identification of A. stilesiana is easy when the insect is perched. The distinctive ochreaceous forewing band can be seen with the naked eye or with binoculars. We have seen individuals of this species during May, June and July.

Acknowledgments: We thank Ruben Canet for supplying us with the holotype and F. G. Stiles for the paratype and the loan of his jeep. A special thanks to R. Mattoni for illustrating the genitalia and two anonymous reviewers. This study was supported in part from a grant to DeVries by the Society of the Sigma Xi and from the University of Texas. Field assistance came from the Museo Nacional, Servicios

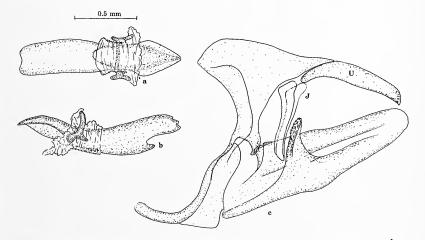


Fig. 3. Genitalia top to bottom: a. Aedeagus dorsal view, b. Ibid, lateral view, c. Lateral view entire genitalia, left valve removed. J = juxta,  $\dot{U} = uncus$ . Scale: 0.5 mm.

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de Parques Nacionales, and L. E. Gilbert. This paper is dedicated to the memory of Bill Evans and T. Monk.

Resumen: Se describe una especie nueva del genero Adelpha (Nymphalidae) del Parque Nacional Braulio Carrillo, Costa Rica. La especie es conocida por solamente dos ejemplares. Se destinga A. stilesiana del A. zalmona sophax, A. melanthe, y A. solmoneus por la banda muy ancha en la ala primaria. Los congeneros de A. stilesiana estan illustradas en Fruhstorfer (1910-1912) y Godman & Salvin (1879-1901). Se comunican algunas observaciones sobre la distribucion y la conducta en su habitat endemica en Carrillo.

### Literature Cited

- DevRIES, P. J., 1980. Description, natural history, and distribution of a new species of *Eretris* (Satyridae) from Costa Rica. J. Lep. Soc. 34: 146-151.
- FRUHSTORFER, H., 1910-1912. In: A. Seitz, ed. Macrolepidoptera of the World. vol. 5. Alfred Kernan, Stuttgart.
- GODMAN F. D. & O. SALVIN, 1879-1901. Biologia Centrali-Americana. Lepidoptera: Rhopalocera, vol. 1, 1879-1886, I-XLV & pp. 1-487; Vol. 2, 1887-1901, pp. 1-782.

### Japanese Literature

The following cited literature is the beginning of a regular listing of relevant papers published in Japan (and usually Japanese) for the convenience of our readership in having available information frequently not readily accessible. Authors' addresses are given for purposes of reprint requests.

"Butterflies and Moths" (Tyo to Ga), volume 32 (1/2), published September 20, 1981.

MASANAO NAKAMURA. Key to the classification of the Japanese lepidopterous pupae. pp. 1-12, in English with a Japanese summary.

Pupae of 75 families comprising 20 superfamilies are keyed and grouped into 6 sections based on external morphology.

KODO MAEKI. The chromosome of the Lepidoptera. pp. 13-28, illusts., in Japanese with an extensive English synopsis.

Reviews the author's evidence for holokinetic, rather than monokinetic, organization of lepidopteran chromosomes.

MAYUMI TAKAHASHI & JUNZO AOYAMA. On Neope niphonica Butler (Lepidoptera: Satyridae) in the Boso Peninsula, Central Japan, with description of a new subspecies. I. pp. 29-47, illusts., in Japanese with the description and a summary in English.

Distribution and morphology of *N. niphonica kiyosumiensis* ssp. nov. are described. Formal description appears on p. 46.

MAYUMI TAKAHASHI. A record of *Tirumala limniace limniace* Cramer (**Danaidae**) from Shizuoka City, Central Japan. p. 48, illust., in Japanese.

An additional record of this rare stray from the Oriental tropics.

TAKASHI SHIROZU & OSAMU YATA. Ten new subspecies of the genus *Eurema* (Lepidoptera, **Pieridae**) from the Indo-Australian Region. pp. 49-62, illusts., in English with a Japanese summary.

Describes E. brigitta papuana (NE Papua New Guinea), E. andersoni inouei (Cambodia), E. andersoni borneensis (Sarawak), E. andersoni nishiyamai (Nias), E. andersoni kashiwaii (Sumba), E. sarilata luzonensis (Luzon), E. sarilata bazilana (Bazilan), E. alitha gunjii (Ceram), E. alitha halmaherana (Halmahera), and E. alitha papuana (W. Irian), sspp. nov. Four forms previously associated with E. hecabe (bidens Butler, sankapura Fruhst., chemys Fruhst., and jalendra Fruhst.) are given new status as sspp. of E. alitha.

HISAKAZU HAYASHI. New lycaenid butterflies from the Philippines. pp. 63-82, illusts., in English.

Describes Deramas treadawayi (Mindanao), D. kawazoei (Marinduque), D. philippinensis (Marinduque), D. toshikoae (Leyte), Narathura schroederi (Palawan), N. cleander sugimotoi (Mindanao and Leyte), N. philippina (Mindanao), N. nishiyamai (Mindanao and Leyte), N. hollowayi (Mindanao, Leyte and Samar), N. pseudovihara (Mindanao), N. sakaguchii (Negros), N. aronya natsumiae (Negros), N. staudingeri negrosiana (negros), N. alesia mio (Negros), Flos setsuroi (Marinduque), Horaga albimacula katoi (Marinduque), Pratapa tyotaroi (Marinduque), Neocheritra kurosawai (Mindanao), Chliaria shirozui

(Mindanao), and Sinthusa mindanensis yoshiae (Negros), spp. nov. and sspp. nov.

SIGERU MORIUCHI. A new Kessleria (Lepidoptera: Yponomeutidae) from New Guinea. pp. 83-84, illusts., in English with a Japanese summary.

Describes K. neuguineae sp. nov. from Wareng, New Guinea, the first sp. of the genus reported from the Island.

RIKIO SATO. Notes on Buzura (Amraica) recursaria (Walker) and its allies from Japan and adjacent countries, with description of a new subspecies (Lepdioptera: Geometridae). pp. 85-93, illusts., in English with a Japanese summary.

Defines B. recursaria (Walker), gives B. superans superans (Butler), B. superans confusa (Stdgr.), and B. asahinai (Inoue) stat. nov., and describes from Formosa B. superans taiwana, ssp. nov.

MAYUMI TAKAHASHI. Inter-specific crossing between Mycalesis gotama fulginia Fruhstorfer and M. madjicosa amamiana Fujioka. pp. 94-100, illusts., in Japanese with an English summary.

Reports the results of reciprocal crosses in captivity (Satyridae).

MAYUMI TAKAHASHI. A gynandromorph of Pieris (Artogeia) melete (Menetries). p. 100, illust., in Japanese.

KENJI KISANUKI. Rearing records of the jacintha-form individuals of the Great Eggfly, Hypolimnas bolina L. pp. 101-107, illusts., in Japanese with an English summary.

Reports the phenotypes, either f. jacintha or f. kezia, of the offspring of f. jacintha females caught in the wild.

MAYUMI TAKAHASHI. A list of the butterflies of Haeterinae and Biinae (Lepidoptera: Satyridae) collected by two Japanese expeditions in Colombia and Peru, South America. pp. 108-116, illusts., in English with a Japanese summary. Thirteen spp. and sspp. are listed with a note on an undescribed form of Pierella hortona Hewitson from South Colombia.

#### Authors' addresses:

Junzo Aoyama	1-137	Nishinota,	Shioya-cho,	Tarumi-ku,	Kobe-shi,	655
	-					

9-1 Tamatsukuri-honmachi, Tennoji-ku, Osaka-shi, 543 Hisakazu Hayashi

Kenji Hisanuki 707 Ogata, Komae-shi, Tokyo, 201 Japan

Kodo Maeki Biological Laboratory, Kanseigakuin University, Nishino-

miya-shi, Hyogo-ken, Japan

Sigeru Moriuchi Entomological Laboratory, College of Agriculture, Univer-

sity of Osaka Prefecture, Sakai-shi, Osaka, 591 Japan

Masanao Nakamura 14-12 Miyamae 3-chome, Suginami-ku, Tokyo, 168 Japan

Rikio Sato 472-2 Makio, Niigata-ken, 950-21 Japan

Takashi Shirozu Biological Laboratory, College of General Education, Kyushu University, Ropponmatsu, Fukuoka, 810 Japan

Mayumi Takahashi 11-13 Kita-Ando 5-chome, Shizuoka-shi, Shizuoka-ken,

420 Japan

Biological Laboratory, College of General Education, Osamu Yata Kyushu University, Ropponmatsu, Fukuoka, 810 Japan

Ichiro Nakamura, compiler, 41 Sunrise Blvd., Williamsville, New York 14221

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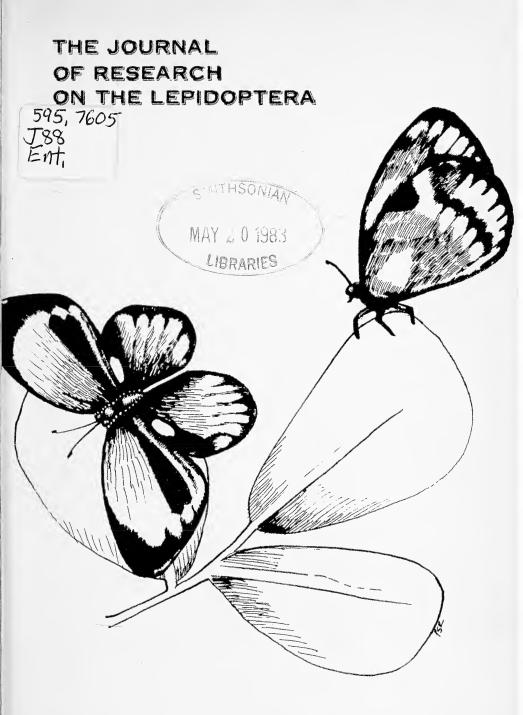
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### Role of an Ornamental Plant Species in Extending the Breeding Range of a Tropical Skipper to Subtropical Southern Texas (Hesperiidae)

Raymond W. Neck

Texas Parks & Wildlife Department, 4200 Smith School Road, Austin, Texas 78744

Human activities have had manifold effects upon populations of various species of lepidoptera. The southern tip of Texas is largely ranching and agricultural with little acreage remaining in a natural state (see Foscue, 1932, 1934). Many agricultural pests affect the growth of these agricultural crops. Several lepidopteran species have apparently increased their natural range as a result of ornamental plants suitable as larval foodplants now occurring in this southern Texas area. Previously, native plants of the proper family or genera were not available.

The blood spot skipper, Phocides palemon lilea (Reakirt), was reported to occur "as a straggler in southern Texas to Arizona" by Holland in the second edition (1931) of The Butterfly Book. No mention was made of this species in his first edition (1898), probably due to lack of collectors along the southern border of the United States at this early date. However, Scudder (1872: 68) had described Erycides sanguinea from "Texas (Capt. Pope, Mexican Boundary Survey)." The specimen(s) may have been collected during the initial boundary survey in the 1850's. Several early collectors failed to find this species, e.g. Lintner (1884). Godman and Salvin (1887-1901: II, p. 296) listed Texas as a questionable locality for Dysennius albicilla (now synonymized with lilea, see Miller and Brown, 1981). A group from the University of Kansas spent 6 June to 8 July 1905 in the Brownsville area collecting insects but did not find lilea (Snow, 1906) Skinner (1911) listed this species and credited Captain Pope. This record was repeated without further remarks by Lindsey, et al., (1931). Klots (1951) did not mention this species, possibly as a result of the negative report of Freeman (1949) who was unable to find this species in field work on both sides of the Rio Grande in the 1930's and 1940's. Nor did Freeman find specimens in several local collections which he examined. Freeman (1951) stated that lilea had been "recorded for Texas, but I have never seen a specimen that actually came from the state." Kendall and Freeman (1963) listed this species in their compilation of Texas butterfly and skipper species. MacNeill (1975:576) stated that this skipper "has long been reported to occur in Texas, but its occurrence there

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has only recently been verified." In a recent letter to the author, Freeman stated "soon after I left the Valley (in 1948)...collectors began collecting this species in goodly numbers." Tilden (1974) reported adults from Brownsville (Cameron Co.) and Santa Ana Wildlife Refuge (Hidalgo Co.).

### **Larval Foodplants**

Common guava (Myrtaceae: Psidium guayava L.) was reported as a larval foodplant at Brownsville by Lipes (1961). This same species is the only recorded foodplant reported for lilea in Mexico (at Puerto Vallarta, Jalisco, by Comstock and Vazquez, 1961; at or near Cd. Mante, Tamaulipas, by Kendall and Maguire, 1975). Recently, Neck (1978, 1982) reported larval utilization of strawberry guava (Psidium cattleianum Sabine), also in Brownsville. A Brazilian subspecies (phanias Burmeister) has been reported to feed on Psidium spp. (Miles Moss, 1949) and Eugenia uniflora L. (Biezanko, 1963).

P. guayava is "indigenous to the American tropics but has been distributed to practically all tropical and subtropical areas throughout the world" (Ruchle, 1948). This plant occurs throughout much of Mexico but is native only in the "southern part" (Standley, 1920-1926). Guava has been grown on both sides of the Rio Grande at least since the late 1800's as both Townsend (1897) and Bailey (1916 but from observations during 1900 trip) mentioned this plant. Plantings may have occurred much earlier as it was spread "early" by the Spanish (Ruchle, 1948). P. cattleianum is native to Brazil but has long been grown in the United States and Mexico (Standley, 1920-1926).

The lack of a native foodplant for lilea in Texas is almost assured because no members of the Myrtaceae are native to any part of Texas (Gould, 1969; Correll and Johnston, 1970). The four alternate plants (papaya, bougain-villea, hibiscus and banana) which Lipes (1961) offered to lilea as oviposition sites (unsuccessfully) are not native to this area, despite his statement to that effect.

### Status of Phocides in Texas

As a result of the lack of a suitable larval foodplant for lilea in the native flora of the lower Rio Grande Valley and the periodicity of the scarce records for lilea in this area, I conclude that lilea is not a member of the native resident skipper fauna of the United States in the strictest sense. This species has extended its breeding range from (probably southern) Mexico into southern Texas. Note that Hoffman (1941: 241-242) reported lilea only as far north as southern Tamaulipas. Following the introduction of guava into Texas, establishment of breeding populations of lilea occurred during the nineteenth century. The paucity of records and absence during the 1930's and 1940's indicate extinction subsequent to initial establishment followed by re-establishment. These earlier popula-

tions could have perished during particularly cold winters, e.g. 1866, 1886 and 1899.

### Discussion

A similar dynamic system of establishment-extinction-establishment has been observed in *Melanis pixe* (Boisduval) (Riodinidae) (Neck, 1976b). In the case of *Melanis*, however, native species related to the introduced foodplant occur in south Texas (two in the same genus, *Pithecellobium*, and numerous species in same family, Leguminosae). *M. pixe* is probably a very recent addition to the fauna of south Texas as no records are known prior to the 1950's.

The dynamic systems of population establishment of these species are indicative of the tropical element of the flora and fauna of the lower Rio Grande Valley. The native tropical element is only a small proportion of the flora and fauna of this region. Many tropical frms are able to maintain populations once they are introduced, e.g. snails and slugs (Neck, 1976a). Exclusion of tropical forms is due to a combination of occasional severe cold winter weather (e.g. 19°F at Brownsville in January 1962) and frequent dry periods which are even more significant since the construction of dams and levees to contain floods of the Rio Grande. In the case of phytophagous insects which are restricted to certain plants as suitable foodplants, the presence of suitable plants is also important.

A dispersal of Dione moneta poeyii (Butler) from central Tamaulipas into south Texas in 1964 was discussed by Gilbert (1969). This species moved far north of its normal range due to unusual weather conditions. Permanent populations were not established because of inherent unsuitability of the south Texas environment. d. m. poeyii is normally found in montane forests. Subsequent reports of this butterfly in south Texas since 1964 are known (R. O. Kendall, pers. comm.). Another exceptional case of long-distance dispersal was witnessed by Freeman (1959) who observed but could not collect a Morpho near Hidalgo, Hidalgo County, on 25 March 1945 (date given by Stallings and Turner, 1946). Similarly, lilea is assumed to have dispersed to south Texas during favorable climatic conditions. Permanent or semi-permanent populations have become established because a suitable larval foodplant is available and other significant environmental factors (which are largely unknown) are not hostile to its continued presence.

Both lilea and M. pixe were found by collectors in the 1950's. The occurrence of these tropical species at about the same time in the lower Rio Grande Valley of Texas may have resulted from peculiar climatic conditions of the 1950's. This period included the worst drought in Texas on record (1950-1957) which was accompanied by very warm winter weather (Orton, et al., 1967). Although severe freezes occurred at Brownsville in late January 1949 and 1951, temperatures fell no lower

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than 29°F (-1.7°C) from 1952-1961 inclusive with no freezing temperatures during 1954-1958 inclusive. Although this was a dry period in general, heavy rains occurred in late June 1954 as a result of Hurricane Alice which moved inland south of Brownsville. This period of warm winters and at least occasional sufficient moisture may have been a significant aid to the establishment of these two species in the Brownsville area. In 1967 tremendous rains accompanying Hurrican Beulah apparently allowed the establishment of several butterfly species previously unknown to Texas (Kendall, 1970a, 1970b, 1972). Several hurricanes which affected the Brownsville area in 1933 had varied impacts on the butterfly fauna of south and central Texas (Neck, 1977).

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### Japanese Literature

"Butterflies and Moths" (Tyo to Ga), volume 32(3/4), published March 25, 1982.

HIROSHI YOSHIMOTO. Notes on the genus *Epipsestis*, with descriptions of three new species from Nepal (Lepidoptera: Thyatiridae). pp. 117-137, illusts., in English with Japanese summary.

Redescribes or describes 10 spp. of the genus here redefined, including *E. dubia* (Warren) sp. rev. and comb. nov.; *E. albidisca* (Warren), *E. bilineata* (Warren), *E. renalis* (Moore) combs. nov.; *E. longipennis*, *E. medialis*, *E. mediofusca* spp. nov. Nepalese *E. nikkoensis* (Matsumura) represents the first record of the sp. outside Japan.

HIROSHI YOSHIMOTO. Notes on the genus *Chandata*, with descriptions of three new species from Nepal and Taiwan (Lepidoptera: Noctuidae). pp. 138-146, illusts., in English with Japanese summary.

The monotypic genus is redefined to include two groups of 2 and 4 spp.: The partita group, C. partita Moore and C. c-nigrum sp. nov.; the bella group, C. aglaja (Kishida & Yoshimoto) comb. nov., C. tridentata sp. nov., C. taiwana sp. nov., and C. bella (Butler) comb. nov.

SHIGERO SUGI. Illustrations of the Taiwanese *Catocala*, with descriptions of two new species. Noctuidae of Taiwan, I. (Lepidoptera). pp. 147-159, illusts., in English with Japanese summary.

Reviews and illustrates all 11 spp. of the genus from Taiwan, including descriptions of *C. naganoi* and *C. shirozui*, spp. nov.

AKIRA YAMAMOTO & SHIN TAKEI. A new species of the genus *Delias* from Mindanao, the Philippines (Lepidoptera, Pieridae). pp. 160-163, illusts., in English. *Delias mandaya*, sp. nov., is described from Tagubud Mts., Southeastern Mindanao.

HIROSHI INOUE. A new species of the genus *Hypochrosis* Guenee from Southeast Asia (Geometridae: Ennominae). pp. 164-167, illusts., in English with Japanese summary.

Hypochrosis baenzigeri sp. nov. is described from Thailand (type locality), Assam, and Taiwan. According to Banziger, the sp. in North Thailand is lachryphagous (feeds on mammalian lachrymal secretion).

SHIGERO SUGI. A new species in the Euteliinae from Japan (Lepidoptera: Noctuidae). pp. 168-170, illusts., in English with Japanese summary.

Describes  $Eutelia\ clarirena\ {\rm sp.\ nov.}$  which occurs from central Japan south to Taiwan and has been erroneously known in Japan as  $E.\ sinuosa\ ({\rm Moore})$ , an Indian sp.

CHRIS SAMSON & ATUHIRO SIBATANI. On the discovery of *Mycalesis sara* Mathew female (Lepidoptera: Satyridae) from San Cristobal Island, Solomon Islands. pp. 171-178, illusts., in English with Japanese summary.

Describes previously unknown *M. sara* female and proposes a solution to the long-standing confusion among related taxa of the Solomons.

ATUHIRO SIBATANI & TAKASHI NISHIZAWA. Delias rileyi Joicey et Talbot, a little known pierid from Irian Jaya. pp. 179-181, illusts., in English with Japanese summary. The specific status of this taxon, originally described from unique male, is con-

firmed by a series of males recently obtained. Female remains unknown.

KAZUHIKO MORISHITA & KAZUHISA OHTSUKA. On the male of *Lethe kinabalensis* Okubo (Lepidoptera: Satyridae). pp. 182-184, illusts., in English with Japanese summary.

Describes the first male specimen of the taxon originally described from two females from Mt. Kinabalu, Sabah, E. Malaysia.

ISAMU HIURA & FUSAO NAKASUJI. A questionnaire on the migration of the rice skipper, Parnara guttata (Lepidoptera: Hesperiidae). pp. 185-189, map, in Japanese with English summary.

Discusses the species' migration patterns and geographic limits of movements in Japan, 1979, based on the results of survey through mailed questionnaires.

KAZUO SAITOH, AZUMA ABE, YOSHINORI KUMAGAI, & SATOSHI KOIWAYA. Karyological notes on Sasakia funebris Leech and Sasakia charonda Hewitson (Lepidoptera: Nymphalidae). pp. 190-192, illusts., in English with Japanese summary.

Number (n = 30) and morphology of the chromosomes of S. funebris from Szechwan, China, are compared with those of the Japanese S. charonda (n = 29).

SHIN-ICHIRO KATO. Notes on the Lycaenidae from Ambon Island, Indonesia. pp. 193-202, illusts., in Japanese with English summary.

Gives an annotated list of 16 genera 22 spp. of lycaenids collected by the author, including 3 spp. previously unknown from the Island.

#### Authors' addresses:

Azuma Abe Hirosaki High School, Hirosaki-shi, Aomori-ken 036, Japan Isamu Hiura Osaka City Natural History Museum, Sumiyoshi-ku, Osaka 546, Japan

Hiroshi Inoue 311-2 Bushi, Iruma-shi, Saitama-ken 358, Japan

Shin-ichiro Kato

4-13-20 Kiyoshikojin, Takarazuka-shi, Hyogo-ken 665,
Japan

Satoshi Koiwaya 3-14-5 Shimotakaido, Suginami-ku, Tokyo 168, Japan Yoshinori Kumagai Namioka Weak Children's School, Namioka-cho, Aomoriken 038-13, Japan

Kazuhiko Morishita 2-2-16 Shinjuku, Zushi-shi, Kanagawa-ken 249, Japan Fusao Nakasuji Entomology Laboratory, Faculty of Agriculture, Kyoyo University, Sakyo-ku, Kyoto 606, Japan

Takashi Nishizawa 4-6-8 Asakusabashi, Taito-ku, Tokyo 111, Japan Kazuhisa Ohtsuka 2-4-2 Shinmachi, Hoya-shi, Tokyo 202, Japan

Kazuo Saitoh Department of Biology, Hirosaki University, Hirosaki-shi,

Aomori-ken 036, Japan

Chris Samson The National Butterfly Museum, St. Mary's, Bramber,

West Sussex BN4 3WE, England

Atuhiro Sibatani 30 Owen Street, Lindfield, New South Wales 2070, Australia Shigero Sugi 41-3 Akadutumi 5-chome, Setagaya-ku, Tokyo 156, Japan Shin Takei 1561 Heathdale Drive, Burnaby, British Columbia V5B

3N9, Canada

Akira Yamamoto 1-18 Nogata 2-chome, Nakano-ku, Tokyo 165, Japan Tokyo High School, 39-1 Unoki 2-chome, Ota-ku, Tokyo,

Japan

Ichiro Nakamura, compiler, 41 Sunrise Blvd., Williamsville, New York 14221

# Hipparchia azorina (Strecker, 1899) (Satyridae) Biology, Ecology and Distribution on the Azores Islands

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### Steffen Oehmig

D-5090 Leverkusen 3, Akazienweg 5, West Germany

Abstract. The present paper deals with the speciation and distribution of Hipparchia azorina (Strecker, 1899). The type locality of H. azorina is restricted to the central island group of the Azores. The eastern island, Sao Miguel, is inhabited by Hipparchia miguelensis (LeCerf, 1935) stat. rev.. Hipparchia caldeirense sp. n. is restricted to the island Flores in the western group. The larvae on Faial, Sao Miguel and Flores feed on Festuca jubata Lowe. Morphology of adults and early stages is described. The habitat of Hipparchia azorina, H. caldeirense and H. miguelensis is described and suggestions regarding their conservation are given.

### Introduction

Hipparchia azorina (Strecker, 1899) was described from a single male specimen, given to Strecker by E. T. Owen, who brought it back from the Azores. Strecker gave "Azores" as the type locality, without any exact data. The synonomy follows:

Satyrus azorinus	STRECKER	1899
Satyrus semele maderensis Bethune Baker;	REBEL	1917:17
Satyrus azorinus Strecker;	WALKER	1931:77
Satyrus azorinus Strecker;	GAEDE	1931:157
Satyrus azorinus Strecker;	LE CERF	1935:206
Satyrus azorinus picoensis	LE CERF	1935:208
Satyrus azorinus miguelensis	LE CERF	1935:208
Oeneis ohshimai	ESAKI	1936:483
Satyrus semele azorinus Strecker;	REBEL	1939:47
Satyrus semele azorinus Strecker;	REBEL	1940a:9
Satyrus semele azorinus Strecker;	REBEL	1940b:16
Hipparchia azorinus Strecker;	LESSE	1952:80
Satyrus semele azorinus Strecker;	CARTHY	1957:210
Hipparchia azorina Strecker;	MARSDEN & WRIGHT	1971:180
Hipparchia azorina Strecker;	KUDRNA	1975:205
Hipparchia aristeus azorina Strecker;	HIGGINS	1975:226
Hipparchia azorina Strecker;	KUDRNA	1977:97
Hipparchia azorina Strecker;	HIGGINS & RILEY	1978:122

In order to study the relationship of the populations inhabiting the Azores in their natural environment, I visited the Azores from June 26th to

July 10th, 1980. The results of this visit and subsequent studies are given below.

### Original description: Satyrus azorinus Strecker 1899

Body, head and antennae black. Wings dark brown. Primaries somewhat dull ochreous on the disk. A small round subapical spot between vein 5 and 6. Secondaries with a strongly sinuate dull ochreous mesial band, this has a deep sinus inwardly between veins 2 and 3, and another at vein 6. Fringe of all wings white, with black termination of veins. The disk and mesial band are not decided or well defined, but dull and suffused, as if showing through from the underside. Under surface, primaries dull pale ochre. Costa brown. At end of and beyond the discoidal cell a brown mark extends from the costa to vein 4. The subapical spot of upper side is repeated, beyond this spot to the costa brown. A brown marginal band, two small white spots interior to this band between veins 6 and 8. Secondaries dark brown, somewhat striated. A mesial band as above but pure white and sharply defined, interior to this band are two white marks, one near the base, is irregular and extends from the costa to within the discoidal cell. The other nearly square is below this in the cell. Fringe as above. Expands 1½ inches. Type, one ♂ received from prof. E. T. Owen, who informs me it came from the Azores. The place for this most interesting species I think would be with or near Satyrus (Chionobas) pumilus, lama, etc. In a remote way it also reminds one of S. neomiris.

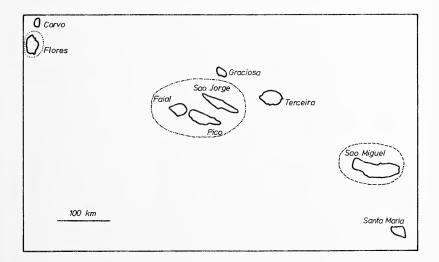


Fig. 1. Distribution of the Hipparchia taxa on the Azores Island. - - - Hipparchia miguelensis, -.-- Hipparchia azorina, ..... Hipparchia caldeirense.

### Distribution

The Hipparchia azorina complex is confined to the Azores. The species complex has been recorded from five of the total nine islands. Their distribution is given in Figure 1. The Azores Archipeligo extends between 36°55′ and 39°44′ north latitude and 25° and 31°15′ west longitude. The distance from Sao Miguel in eastern group to Pico Island in the central group is approximately 250 km. Pico island is another 250 km from Flores island in the western group. These distances clearly demonstrate the dispersal required for the insects to settle upon these islands. It is possible, according to the hypothesis of Gatter (1981), that the drifting form of migration (the carrying of the insects by the northeast tradewinds) is responsible for establishment of Hipparchia on the various islands. A recent good example of this form of migration is the colonisation of Madeira by Pieris rapae as documented by Wolff (1975). A few years later Higgins (1977) and Oehmig (1977) reported the reestablishment of Pararge aegeria on Madeira.

### Populations of the Islands

### **PICO**

Hipparchia azorina (Strecker 1899) stat. rev.

Lepidoptera Rhopalocera and Heterocera indigenous and exotic. Suppl. 3:3.

Satyrus azorinus picoensis LeCerf, 1935, Bull. Soc. ent. Fr., 40:206-209. Syntypes  $2 \, \sigma \sigma$ ,  $1 \, \varphi$ , [Azores], Pico, Museum National d'Histoire Naturelle, Paris.

Description:  $\sigma$ : upperside forewing dark brown, but never as dark as the males from the Faial populations. Discal and postdiscal area with a pale ochre yellow color. Occasional specimens appear with a lightened basal area. In cell 6 a dark brown spot, sometimes as eye spot.  $\sigma$ : upperside hindwing dark brown postdiscal area light ochre. In cell 2 sometimes a dark brown spot.  $\sigma$ : underside forewing range from a pale to a strong ochre, always lighter than the males from the Sao Miguel populations. The dark brown eyespot in cell 6 or the spot in cell 2 often absent. Outer margin more or less sharply defined.  $\sigma$ : underside hindwing basal and discal area dark brown and project pointed into the white postdiscal area. Females were not found on the Pico island during this study, therefore they shall not be described here.

Androconial scales: length: 0.14-0.16 mm, width: 0.015 mm. Androconial patch is not always present. Although small, the androconial form is similar to that of males of Sao Miguel population.

Male genitalia: Valva length: 1.8 mm, width: 0.3 mm. The valva are distinctly narrower than in *Hipparchia miguelensis* LeCerf, 1935. The dorsal process on the valva is mostly rounded off and not as pointed as that

of the Sao Miguel specimens.

Distribution: Pico, Azores, from 600 m on, upwards to 2000 m. Cabeco do Encalvado 900 m. Walker (1931) Serra Gorda, Cabeco do Afonso, O Pico. On Pico up to an altitude of 2000 m; LeCerf, 1935. Males only were observed on the northern high plateau of the island. Vegetation on the northern slope of Pico predominantly consists of Calluna vulgaris (L.) Hull. amongst Pteridium aquilinum (L.) Kuhn and Erica azorica Hochst. ex Seub., which grow up to 3 meters tall. Walker (1931) states that specimens from Cabeco do Afonso and Serra Gorda were found only singly "on the S. and SE. of the mountains we found it much commoner". Rebel (1940b) cites Silveira and Lagoa do Caiado on Pico island. The main habitat, however, is found on the southern slopes of Pico island, protected against the northeast tradewinds. The early stages of H. azorina on the Pico island remain unknown.

Discussion: Since Strecker (1899) gave as type-locality "Azores", it is necessary to identify and restrict the exact place for taxonomic clarity. The holotype was not inspected directly. However, black and white and color slides of the holotype were available for comparison. The genitalic preparation of the holotype showed great similarity indeed with the genitalia of males from Pico. The holotype was examined by Kudrna (1977), who also examined my material from Pico. In addition the original description of H. azorina (Strecker, 1899) agrees very closely with males from Pico, "wings dark brown, primaries somewhat dull ochreous on the disk, under surface, primaries dull pale ochre". Males from Flores as well as males fom Sao Jorge are lightly ochreous colored. The Faial males certainly have a stronger ochre coloring on the underside of the forewings, while their upper surfaces are always dark brown. I propose to restrict the type locality of H. azorina to Pico.

Material examined: 6 oo, forewing length: 21-22 mm, leg. et coll. S. Oehmig, Azores; Pico: Cabeco do Encalvado 9000 m: 2 July 1980.

Appearance: June-September, possible longer.

#### FAIAL

Hipparchia azorina ohshimai (Esaki 1936) comb. nov., stat. nov. Oeneis ohshimai Esaki 1936, Annotnes. zool. jap. 15(4):483-485 [Azores]: Faial; Caldeira, Pico Gorda: 1021 m; 24 Aug. 1935 and 30 Oct. 1935, leg. H. Ohshima. Holotype  $\sigma$ , Allotype  $\varphi$ , Paratypes  $2\sigma\sigma$ ,  $3\varphi\varphi$ , Entomological Laboratory, Kyushu Imperial University, Fukuoka, Japan.

Description:  $\sigma$ : upperside forewing color dark blackish-brown, in cells 6 and 2 dark brown spots, some without these spots.  $\sigma$ : upperside hindwing color dark blackish-brown. Postdical area from the underside weakly translucent.  $\sigma$ : underside forewing pale to middle ochreous color, but not so strong ochreous as the forewing underside from the Sao

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Miguel males, with a fine dark brown zigzag postdiscal line. Outer margin dark brown, project into the postdiscal region, and is not sharply defined. Some with a narrow outer margin band.  $\sigma$ : underside hindwing, basal and discal area blackish brown, always taper off along the discoidal and median veins projecting into the white postdiscal area. The basal area has white spots.  $\varphi$ : upperside forewing dark brown. Discal and postdiscal area lighter than the males. In cell 6 a dark brown spot or eyespot, in cell 2 a dark brown spot.  $\varphi$ : upperside hindwing dark brown, but lighter than the males.  $\varphi$ : underside forewing light ochre with a dark brown zigzag band. Outer margin dark brown, sharply defined. Spots from the upperside sometimes absent.  $\varphi$ : underside hindwing basal and discal area dark brown, lighter than the males. Outer margin light brown to dark brown.

Androconial scales: length: 0.13-0.14 mm, width: 0.02 mm. Androconial form is somewhat stunted. The androconial patch is often divided into two patches along the median veins in cell 2 and cell 1b. Many specimens appear without an androconial patch. Spatulate androconial scales have been observed, such forms being unique to males from Faial.

Male genitalia: Valva length: 1.8 mm; width: 0.4 mm. The valves differ from those of specimens from Flores and Pico in their greater width; the dorsal process terminates in a point.

Female genitalia: Signum length: 1.2 mm; width: 0.15 mm. Smaller than the signa from the Sao Miguel females.

Distribution: Azores, confined to Faial from 700 m to over 1000 m, (Walker, 1931) Caldeira southern inclines 900 m, (Esaki, 1936) Caldeira, Pico Gorda 1021 m, (Rebel, 1940b) above Horta, Caldeira. I found this subspecies very common on the southern slopes of the Caldeira at 900 m. The butterflies fly frequently on the south eastern slope of the Caldeira on Pico Gorda. In the Caldeira there are only single specimens in the cliffs of the upper crater wall. The biotope here gives the impression of a mountain meadow. Festuca jubata Lowe. is abundant, as is Calluna vulgaris. Daboecia azorica Tutin & Warb. grows round in nest form with red blossoms in summer. The cliffs are often extremely rugged from water erosion. The grass vegetation also includes occasional plants of Potentilla sp. The biotopes of Faial island differ clearly from the biotopes of the other islands in special vegetation.

Early Stages: Ovum: Diameter: 1.1 mm; height: 1.1 mm. The terminology follows Doring (1955). The egg form is a half elliptical barrel shape with a convex egg base. The top view is circular with longitudinal ribs, extending from the base to just below the micropylar area, although some ribs do reach the micropylar area. The ribs are in longitudinal ridges with two rows in binded aeropyles. The chorion is provided with fine hardly visible cross lines. Number of ribs, 24. The taxonomic importance of the micropyles is indicated by Hinton (1981). In many species the number may be constant, and could therefore be used as a reliable taxonomic character.

However, I have also noticed some species in which the number of micropyles varies within all the eggs of a female. Four micropyles have been counted in the Faial ova, the micropyle rosettes are seven leaved. The ova are individually attached by the females to the foodplants. The base of the ovum is somewhat adhesive. Eggs are always deposited on plants protected from the wind. Fifteen days elapsed to hatching under handling conditions. The egg is white at first, then becomes dappled with light red-brown, and shortly before hatching it is grey-brown. In the field females cease oviposition when the sun disappears behind a cloud. Egg deposition stretched into evening under artificial light. In the laboratory Faial females lay 60-70 eggs.

- (L1) first instar: Body length: 3-4 mm; final L1: 6 mm. Duration: 21 days. The larva hatches through a circular gnawing of the chorion on the micropylar area. Usually a cross-piece remains hinged, forming an emergence lid, although sometimes the chorion is entirely gnawed through forming a hole. The chorion itself is not consumed. Emergence of the larva can only occur under humid conditions. Arid conditions inhibit and may even prevent the emerging. The description of the line patterns of the larva follows Shirozu & Hara (1979), Fig. 2, and the description of the head is according to Beck (1974). The coloring of the larva is that of a light sand. Dorsal, subdorsal, subspiracular and spiracular lines are all light brown. The end of L1 is light brown as well. The head capsule has four primary setae on either side of the genae, head diameter 0.8 mm. The dorsal side of the body has four rows of setae, and on the fifth segment of the ventral side there are 6 setae, which are turned caudally. The anal segment is forked, with two setae on each side. The L1 head capsule of Hipparchia semele L. has the same number of primary setae as the Hipparchia taxa from the Faial, Flores and Sao Miguel islands. In complete contrast, the genus Pseudochazara exhibits primary fine hairs which are very strongly pronounced (Aussem & Hesselbarth, 1980).
- (L2) second instar: Body length: 5 mm; final L2: 8-9 mm. Duration: 17 days. The coloring and line patterns of the body are as in L1, although now there is an additional pale white basal line. The head is light brown, diameter 1 mm. The density of pubescence increased. Genae are marked on either side with light brown coronal lines, supraocellar lines and ocellar lines. Anal segment is forked.
- (L3) third instar: Body length: 9 mm; final L3: 14 mm. Duration: 17 days. Coloring and marking of the body as in L2. Head capsule diameter, 1.5-1.6 mm. The dorsal line often interrupted or dotted. Head capsule dark brown and more pubescent than L2. The lines of the head capsule as in L2. Abdominal fine hair no longer present. Anal segment is forked.
- (L4) fourth instar: Body length: 13 mm; final L4: 18 mm. Duration: 16 days. The color is usually dark brown with a few light brown individuals. Dark brown dorsal line often interrupted. Subdorsal line light brown;

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subspiracular line dark brown, as broad as dorsal line. The spiracular line light brown, narrow white basal line distinct. Head capsule dark brown. The genae lined patterns as in L3 densely pubescent. The fine hair on the body equally abundant. The anal segment forked. From L4 on, the sexes differ in diameter of head capsule:  $\mbox{CO} \mbox{CO} \mbox{2.1 mm}, \mbox{QQ} \mbox{2.5 mm}.$ 

(L5) fifth instar: Body length: 25 mm; final L5: of 27 mm, \$\text{Q}\$ 30-32 mm. Duration: 26 days. Head capsule diameter: ♂♂ 3.5 mm, ♀♀ 5 mm. Dimorphic, both dark and pale brown forms present. Dorsal line dark brown bordered by two thin white lines occasionally dotted and interrupted. Subdorsal line dark brown, supraspiracular line also dark brown with two fine white border lines. White basal line bordered by two thin dark brown lines. Thin, short dark brown marks present between dorsal line and spiracular line. Body thickly covered with short bristly hair. Both dark and pale brown head capsules observed. On either side of the genae there is a coronal line, supraocellar line and ocellar line. These markings are dark brown, and in many specimens are so wide and so dark that the head appears to be entirely black-brown. The head has a dense covering short red-brown hair. The bristles of the Faial specimen, however, are somewhat longer than those of the L5 instar of the Sao Miguel and Flores populations. Males and the females are easily distinguishable by the width of the head.

Prepupa and Pupa: During the prepupa stage the markings of the larva become lighter and more translucent as the body of the larva contracts and thickens. Under laboratory conditions the prepupa lasts 10 days. In comparison with the pupae from Sao Miguel, the Faial pupae are dark brown in coloring, although there is some variation. On the dorsal and lateral sides of the abdominal segments the Faial pupae have dark brown pigment markings. On each segment there are up to 10 marks in a double row. The abdomen of newly formed pupa is capable of movement. Pupation occurs without the preparation of a web, between the leaves of Festuca jubata Lowe. Occasionally pupation takes place in open ground. In most cases in the field a grassy area sheltered from the wind is selected for pupation. In the beginning of July 1980 I found L5 larvae capable of pupation and pupae at an elevation of 900 m on the southeast slopes of the Caldeira. Under laboratory conditions, at temperature of approximately 20°C, the pupal state lasts 21-30 days. The pupae require a humid environment. If they become too dry, the butterflies cannot eclose properly, or emerge crippled. This could be the result of adaptation to the moist often damp ground vegetation of the Azores mountain regions. Pupa length/width (mm): ♂♂ 15/6; ♀♀ 17/7.

Adult Material Examined: 45 od, forewing length: 20-22 mm. 25 99 forewing length: 21-24 mm. Leg. et coll. S. Oehmig, Azores, Faial, Caldeira, southeast slope 900 m, 1 July 1980.

Discussion: The dark color of the male upperside is peculiar to Faial

specimens. The stunted form and small size of androconial scales is so different compared with androconial scales of the *Hipparchia* taxa of the islands of Pico and Sao Jorge, that separation of this taxon from the others is justified.

Foodplant: Festuca jubata Lowe. (Gramineae).

Appearance: June-October.

#### SAO JORGE

### Hipparchia azorina jorgense Oehmig new subspecies

Holotype  $\circ$ ; Paratypes  $\circ$ , 8  $\circ$ 9; [Azores]: Sao Jorge, Coroas 600 m, leg. D. T. Pombo, 2 Aug. 1981, Nord Biscoitos Transversal, leg. D. S. Furtado, 26 Aug. 1981. All types in my collection.

Description: or: upperside forewing dark brown, discal region ranges from a light ochre to a sand color. In cells 6 and 2 a dark brown spot. The light sandy colored discal region is typical of the specimen from Sao Jorge. of: upperside hindwing dark brown, postdiscal band is a striking light sandy color.  $\sigma$ : underside forewing very pale ochre, with an eyespot in cell 6 and a dark brown spot in cell 2. Outer margin dark brown is alwyas narrow and sharply outlined. or: underside hindwing basal and discal area dark brown. A characteristic which only occurs amongst the Sao Jorge specimens is that the pale white postdiscal band is laid very broadly. The discal area runs along the discoidal and median veins tapering off into the white postdiscal band. 9: upperside forewing light ochre to sandy colored discal and postdiscal area. In cells 6 and eyespots or spots in brown color. Q: upperside hindwing, a pale postdiscal area is typical as well for these specimens. 9: underside forewing quite pale ochre to sandy color. In cell 6 and 2 brown eyespots or spots. Outer margin brown sharply defined. 9: underside hindwing basal and discal area dark brown. The discal area project pointed into the white postdiscal area.

Androconial scales: length: 0.14-0.15 mm; width: 0.018 mm. Androconial patch small not always present. The form and size is similar to that of the Faial males. At the base however, the form is never spatulate round, rather it is always pointed.

Male genitalia: Valva length: 1.3 mm; width: 0.35 mm.

Female genitalia: Signum length: 1.3 mm; width: 0.2 mm.

Distribution: Azores, Sao Jorge, from 480 m to over 700 m. Marsden & Wright (1971) between Urzelina and Ouvidor, Mr. Pombo, Coroas 600 m leg. 2 Aug. 1981, Mr. Furtado, Nord Biscoitos Transversal, leg. 26 Aug. 1981. The only information concerning the Hipparchia biotopes of the island of Sao Jorge are based on the results of Marsden & Wright (1971), who reported the habitat of Hipparchia azorina is to be found from the upper Callunetum-Ericetum pasture to the Agrostis pasture zone. The lower boundary was specified by the authors as being at 480 m on the northern slopes, and 540 m altitude on the southern slopes. The number of

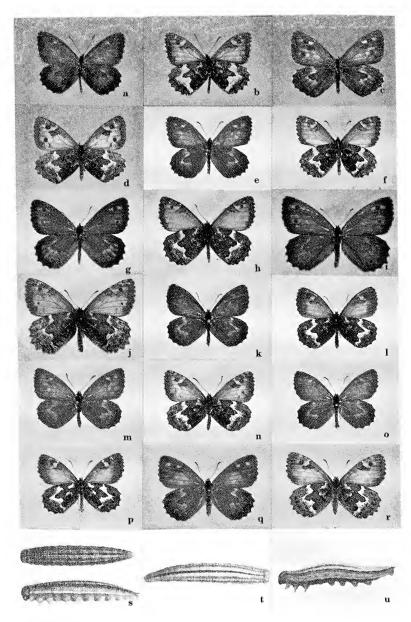


PLATE I.

PLATE I. Imagines of the Azores Hipparchia taxa.

- a. H. azorina jorgense, o upperside
- b. H. azorina jorgense, & underside
- c. H. azorina jorgense, ♀ upperside
- d. H. azorina jorgense, Q underside
- e. H. azorina, o upperside
- f. H. azorina, o underside
- g. H. miguelensis, & upperside
- h. H. miguelensis, & underside
- i. H. miguelensis, ♀ upperside
- i. H. miguelensis, ♀ underside
- k. H. azorina ohshimai, o upperside
- 1. H. azorina ohshimai, o underside
- m. H. azorina ohshimai, ♀ upperside
- n. H. azorina ohshimai, ♀ underside
- o. H. caldeirense, & upperside
- p. H. caldeirense, o underside
- **q.** H. caldeirense,  $\mathcal{P}$  upperside
- r. H. caldeirense, ♀ underside
- s. H. azorina ohshimai, 5th instar
- t. H. miguelensis, 5th instar
- u. H. miguelensis, 5th instar

Figures a-r: 0.6 X natural size. Figures s-u: 1.05 X natural size.

flying adults observed per 3 minute at varying altitudes taken from Marsden & Wright (1971) is as follows: Between 480-540 m, fewer than 10; at 720 m, on the southern side, approximately 30; and on the northern side, 85 adults.

Based on these results, it is apparent that the *Hipparchia azorina* population of Sao Jorge occur most frequently at an altitude of approximately 700 m. The above authors also provided data concerning the temperatures at the high altitude of 700 m, during the month of September. Under clear skies the temperature may drop as low as 7°C with 24°C as the daytime high temperature. One may assume, because larval feeding occurs exclusively during the night, that by September the larva have already gone into diapause. Under laboratory conditions at a temperature of 20°C, 10 weeks are necessary for the development to the third larval stage. An egg, deposited at the beginning of July, would thus be expected to reach a maximum third larval stage by mid September.

Material Examined: Holotype  $\circ$ , forewing length: 22 mm, [Azores], Sao Jorge, Coroas 600 m, 2 Aug. 1981, leg. Mr. D. T. Pombo, Santa Maria, Azores. Paratypes  $\circ$  and  $\circ$  leg. Pombo,  $\circ$  1981 leg. Mr. D. S. Furtado, Sao Miguel, Azores, Nord Biscoitos Transversal, 26 Aug. 1981. Male forewing length: 22 mm, female 23-26 mm. All types in my collection.

Discussion: Specimens of Sao Jorge are, with respect to the pale

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forewing upperside and the wide postdiscal area on the hindwing underside, clearly different from the *Hipparchia* taxa of Pico and Faial. Both androconial scales and male genitalia also show differentiation between the taxa of Pico and Faial. These characters justify a distinct subspecies.

Foodplant: Not known, probably Festuca jubata (Gramineae). Appearance: June-September.

### SAO MIGUEL

### Hipparchia miguelensis (LeCerf, 1935) stat. rev.

Satyrus azorinus miguelensis LeCerf, 1935, Bull. Soc. ent. Fr., 40:206-209 [Azores]: Sao Miguel.

Holotype  $\sigma$ , Allotype  $\circ$ , Paratypes 2  $\sigma\sigma$ , Museum National d'Histoire Naturelle, Paris.

Description: o: upperside forewing dark brown, but not so dark as males from Faial and Pico, in cell 6 a dark brown eyespot or spot, in cell 2 a dark brown spot. The ocelli of some of the specimens have a strong, underlying ochre yellow color. Some males are rather similar to the females due to the distinct ochre yellow markings which they exhibit. Most males, however, are without this strong ochre yellow marking. or: upperside hindwing dark brown, some with a dark ochreous postdiscal area, in cell 2 a dark brown spot. or: underside forewing dark ochre yellow, typical H. miguelensis. In cell 6 a evespot, in cell 2 sometimes a dark brown spot. Outer margin dark brown and sharply defined. Costa dark brown. : underside hindwing basal and discal area dark brown, but lighter than the Faial taxa. The discal area always terminates round into the white or pale ochre postdiscal area. 9: upperside forewing dark brown, as in the males. In cell 6 an eyespot, in cell 2 a brown spot. The spots of the specimens have a strong underlying ochre color. The ochraeous colored markings of the females are more pronounced than those of the males. 9: upperside hindwing dark brown with more or less strong ochre postdiscal area. In cell 2 a dark brown eyespot. 9: underside forewing strong ochre yellow with a finely marked ochre zigzag pattern in the postdiscal area. In cell 6 an eyespot, in cell 2 a dark brown spot. Outer margin dark brown, sharply defined. 9: underside hindwing basal and discal area dark brown. The discal area between cells 3 and 4 along the discoidal and median veins are always bluntly rounded off, reaching into the light cream colored postdiscal area.

Androconial scales: length: 0.17-0.19 mm; width: 0.015 mm. These are the largest androconial scales of all the taxa from the Azores. Androconial scales wide and strongly tapered off toward the apex. The androconial patch is most clearly pronounced of all taxa, but not very large. There are two along the median vein of the cell.

Male genitalia: Valva length: 2.25 mm; width: 0.45 mm. The valva is

wider than those of the other taxa from the Azores. The terminal extension is always short in form. The dorsal process is well pronounced, and tapers off to a point. The uncus is always distinctly longer than in the taxa of the other island.

Female genitalia: Signum length: 1.6 mm, width: 0.2 mm. Longer and broader than those of the other taxa.

Distribution: Sao Miguel, Azores, from 600 m to over 1000 m. Gafanhoto 715 m, Vista do Rei 600 m (Rebel, 1940b):17, Lagoa do Fogo 700 m, Pico da Vara 1103 m. The important environment requirement of H. miguelensis populations is the presence of Festuca jubata. This plant shows substantial variation in composition and aspect in the habitats where it is found amongst the islands; from the grassy meadows in the mountains to plant associations which form thickets, and where Festuca jubata itself only plays a minor role (Lupnitz, 1975a). In the Vale de Furnas, Gafanhoto 700 m, southern exposure, the habitat is in a densely wooded zone. Laurus azorica (Seub.), which stands approximately 2 meters tall, grows in wide intervals together with Vaccinium cylindraceum Sm., and Rubus sp. In between grows Calluna vulgaris (L.) Hull. which intertwines to practically form a surface. Festuca jubata prospers in thickets amongst Blechnum spicant (L.) Roth., Osmunda regalis L., Woodwardia radicans (L.) Sm. individual Heydichium gardnerianum Roscoe and Potentilla sp. Close to the ground are often Selaginalla sp., Sphagnum sp. and Lycopodium sp. In most places the ground is heavily covered with foliage. On account of frequent precipitation the vegetation is often dripping wet for the entire day. These plant communities can be found near Pico da Vara. The butterflies, although fewer in number, fly as well on the Vista do Rei. The habitat is small, perhaps a vestigial environment. Many Lotus uliginosus Schuhr and Lotus parviflorus Desf. are in bloom, and Festuca jubata is also present. Single butterflies have also been observed at the inaccessible western crater-wall of the Sete de Cidades.

Ovum: diameter: 1.1-1.2 mm; height: 1.1 mm. Micropyles 3. Micropyle rosettes five leaved. There are 26 ribs in longitudinal ridges. The form and coloring is as in the Faial specimens.

Larva: The development of the larvae from the Hipparchia miguelensis populations corresponds to that of the population from Faial. The markings of the larva also coincide with those of the larvae from Faial. However, in contrast to Faial larvae, the 5th instar of the Sao Miguel larvae are always a light sandy color with a pattern of light brown lines. The head capsule is always a pale red-brown. The fine hair of the head capsule is shorter in the 5th instar than in the Faial 5th instar. In most larvae, the coronal line and the supraocellar line do not meet in the height of the ocelli, as is the case of the Faial population.

Pupa: The Sao Miguel pupa is always light brown in color. In contrast to the Faial pupa, the dorsal abdominal markings are not present, or are at

least very indistinct. Pupa, length/width (mm): od 15/16; 99 17/7.

Material Examined: 90 °C, forewing length: 22-25 mm; 8 9 forewing length: 24-28mm. Leg. et coll. S. Oehmig, Azores, Sao Miguel, Gafanhoto 700 m, 27 June 1980.

Discussion: Typical for H. miguelensis is the large signum of the females, and the large uncus and the wide valva of the males. The androconial scales are the largest of all the taxa of the islands. The ovum shows 26 ribs and 3 micropyle openings. The micropyle rosette is five leaved. The 5th instar larva, including its head capsule, is a great deal lighter in color than the other taxa. The fine hairs of the head capsule of the last instar are shorter than hairs of the head capsule from the Faial larvae. It is clear that a distinction is in order differentiating this taxon from H. azorina based upon the divergent coloring and markings of the larva, as well as the completely different appearance of the imagines.

Foodplant: Festuca jubata (Gramineae)

Appearance: June-September.

It can surely be assumed that the *Hipparchia* appearing on the Azores islands are of allopatric distribution. The concept of superspecies (Mayr, 1967) should be applied here. Mayr has indicated that the superspecies concept be especially applied to the pattern of variation associated with insular distribution patterns.

## **FLORES**

## Hipparchia caldeirense Oehmig new species

Holotype  $\sigma$ , Paratypes 33  $\sigma\sigma$ , 6  $\varphi\varphi$ ; [Azores], Flores, Caldeira Seca, 700 m, 30 June 1980, leg. et coll. S. Oehmig.

Description: or: upperside forewing dark brown, basal and discal area lighter ochre. In cell 6 a dark spot, sometimes with underlying of light ochre color. In cell 2 a small dark brown spot, however the spot is not present in all specimens. or: upperside hindwing dark brown color, the postdiscal area is only poorly visible. Some specimens with a dark brown spot or eyespot in cell 2. or: underside forewing light ochre yellow color in the basal and discal region. The outer margin borders on a dark brown area, which always broadly reaches into the postdiscal area, and is not sharply defined. The brown spot in cell 2 is never present. F: underside hindwing basal and discal region dark brown with distinct white markings in the basal region. This is a typical characteristic of the specimens from Flores, and appear only rarely in specimens from Pico island. The dark brown discal area runs along the discoidal and median veins, tapering to a point and project into the white postdiscal area. 9: upperside forewing color like the males, but somewhat lighter ochreous in color; dark brown spots in cells 6 and 2 larger than the males. 9: upperside hindwing like the males. 9: underside forewing like the males but the outer margin is not as broad and dark as the males.  $\varphi$ : underside hindwing like the males but somewhat lighter in color.

Androconial scales: Not present. One may assume that they were lost secondarily.

Male genitalia: Valva length: 0.17 mm; width: 0.2 mm. The Flores specimens are distinguished by their valves which are the narrowest of all the Azores taxa. The terminal extension is especially long.

Female genitalia: Signum length: 1.3 mm; width: 0.1 mm.

Distribution: Flores, Azores, Caldeira Seca 700 m and above. The butterflies fly along the inclines of the Caldeira Seca and the Pico dos Sete Pes, from altitudes of 700 m and more. The environment is pervaded with valleys formed by erosion. The vegetation is rich in grass and Festuca jubata, which grows in dense thickets, is quite common. In the eroded valleys by water one can find the following shrubs: Laurus azorica, Viburnum tinus L., Rhammnus gladulosa Ait., Rubus sp., and occasionally Vaccinium cylindraceaum. Dwarfed Juniperus brevifolia (Seub.) Ant. and Erica azorica can be found in the back of the valley, Calluna vulgaris appears as well and occasionally one finds Potentilla sp. In some areas the environment resembles a fen. A thick cushioning is often built on the ground by Spaghnum sp. With exception of the protected valleys the environment gives a barren impression, and is barely protected from the tradewinds. As a result the butterflies remain primarily in the protected valleys, however when they do fly out of the valley, then they are often carried quite some distance by the wind.

Ovum: diameter: 1.0 mm; height: 1.0 mm. The form and coloring is similar to that of the specimens of Faial and Sao Miguel. There are 24 ribs in longitudinal ridges, two micropyl openings, micropyle rosettes are 4 leaved.

Larva: The development of the Flores larva corresponds to the larval development of the taxa from Faial and Sao Miguel. The Flores larva are much lighter in coloring than the larvae from Sao Miguel. In this respect the Flores larvae are similar to those of Sao Miguel.

Pupa: The pupa is always light brown in color. The distinctly pronounced abdominal markings of the Faial pupae are barely visible or are not present. Pupa length/width (mm): ♂♂ 13/6.

Material Examined:  $34 \, \mbox{cd}$ , forewing length:  $19\text{-}22 \, \mbox{mm}$ ;  $6 \, \mbox{QP}$ , forewing length:  $23\text{-}24 \, \mbox{mm}$ . Holotype  $\mbox{cd}$ , forewing length  $21 \, \mbox{mm}$ , and paratypes. Azores, Flores, Caldeira Seca,  $700 \, \mbox{m}$ ,  $30 \, \mbox{June 1980}$ , leg. et coll. S. Oehmig.

Discussion: On account of the morphological differences between the imagines, it is reasonable to separate H. caldeirense from Hipparchia azorina. In particular the extremely narrow valves of the males and the small signum of the females justify separation. The complete absence of the androconial scales can be seen as a barrier to the mating of the Flores

taxon with the *Hipparchia* populations of the other Azores islands. Tinbergen (1941) has shown that *H. semele* L. males, from whom the androconial scales have been removed, are still capable of mating. However, in comparison with the males which still possess the androconial scales, the former are clearly at a disadvantage in mating. A further feature supporting the separation of *Hipparchia caldeirense* from *H. azorina* is the different structural character of the ovum upper surface.

Foodplant: Festuca jubata Lowe (Gramineae).

Appearance: June-September.

## Foodplants-Adults and Larvae

The imagines of all Hipparchia populations from all the islands primarily visit the blossoms of Rubus ulmifolius Schott and Rubus hochstetteranum Seub., as well as Potentilla erecta (L.) Raesch and Potentilla anglica Laicharding as their nectar sources. On Sao Miguel I observed individual butterflies as they fed from the blossoms of Calluna vulgaris. All of the habitats are quite poor in the flowering plants, which give rise to questions of nutrition for the adult butterflies. Present in the environment are also the following blossoming plants, which by observation are not visited by the butterflies for feeding: Vaccinium cylindraceum on Flores and Sao Miguel islands, Thymus caespititius Brot. on Pico, and Daboecia azorica on Faial and Pico islands. The females prefer grass cushioned areas, which are compact and not too large, for oviposition. Oviposition in all observed cases is confined to Festuca jubata.

The feeding of the larvae always begins at the tip of the leaf and continues down approximately 1/3 of the length to the plant base. If there are several larva in the plant, then the surface is eaten away quite evenly. The larvae of Hipparchia azorina were found on Faial island at the southeastern slopes of Caldeira at 900 m altitude on July 1, 1980, in the grass cushioning of Festuca jubata Lowe. Up to five larvae were found on a single plant, but usually one finds only one or two larvae per plant. The larvae appear to favor plants which grow in wind protected rivulets or valleys. Marsden & Wright (1971) have already pointed out the strong feeding activity of the larvae upon the grass vegetation. Economic damage by Hipparchia larvae to the grass vegetation is not cited. It appears likely that the larvae of all the Hipparchia populations on the various Azores islands feed monophagously on Festuca jubata, which grows only in montane regions. On the coast it is replaced by Festuca petraea Seub. On Sao Miguel, Faial and Flores several females were taken for egg laying, the eclosed larvae being available during the author's visit to the Azores. In breeding these larvae, first on Madeira and later in Germany, the problem of foodplants presented itself. Festuca jubata was no longer available, and Festuca ovina L., which occurs in Germany, was not accepted as nutriment.

Summary of characteristics of the Azore Island taxa of Hipparchia, Table 1.

	Hipparchia caldeirense	Hipparchia azorina ohshimai	Hipparchia azorina jorgense	Hipparchia azorina	Hipparchia miguelensis
Distribution	Flores	Faial	Sao Jorge	Pico	Sao Miguel
Forewing length (mm)	ởở 19-22 ♀♀ 23-24	20-22 21-24	22 23-26	21-22	22-25 24-28
Forewing color upperside	dark brown basal and discal area, light ochre	dark brown	dark brown very light ochre postdiscal area	dark brown with light ochre discal area	dark brown eyespot markings always dark ochre
Androconial scales length/width (mm)	not present	0.13 - 0.14 X 0.02	0.14 - 0.15 X 0.018	0.14 - 0.16 X 0.015	0.17 - 0.19 X 0.015
Valva length/width (mm) $1.7 \times 0.2$	$1.7 \times 0.2$	1.8 X 0.4	$1.95 \times 0.35$	$1.8 \times 0.3$	$2.25 \times 0.45$
Uncus length (mm)	0.8	0.95	6.0	6.0	1.3
Signum length/ width (mm)	$1.3 \times 0.1$	1.2 X 0.15	1.3 X 0.2		1.6 X 0.2
Ovum height X diameter (mm)	1.0 X 1.0	1.1 X 1.1	compo tenne		1.1 - 1.2 X 1.0
Micropyles	7	4			ಣ
Ribs	24	24		-	26
Larva color	light brown	most dark brown	-	******	light brown
Pupa length/width (mm)	o 13/6	15/6		SECTION AND AND	15/6
	01	17/7			17/7

Festuca scoparia Kerner et Hack, from the Pyrenees, was the first plant the larvae accepted. All the bred specimens have been reared with this plant.

## Behavior of Larvae

The larvae are nocturnal. On July 1, 1980, toward 1800 hours on Faial island I found L5 instars of *H. azorina* hidden in the cushioning grass. Sometime after dusk the larvae wander out of the middle of the plants in order to eat from the tip of the leaves. In such fashion they work their way down towards the base of the plant, minimizing visible evidence of damage and their presence. During the day the larvae hide in the grass with their heads facing upward. In cases of heavy feeding by the larvae, up to ½ of the total height of the cushioning grass can be eaten away. While still dark, after feeding, the larvae wander back inside the grass cushion.

#### **Behavior of Adults**

The flight of the butterfly begins as soon as the sun breaks through in the early morning hours. The butterflies interrupt their flight during sudden rainstorms, but continue to fly during light drizzles. When adults rest they prefer to settle down on plants. The butterflies always fly on the regions of the mountains which are protected from the wind. The flight is short and after a short flight the butterflies land again. The butterflies take a slanting position of  $45^{\circ}$  with their wings shut as they alight. They fly always more or less close above the ground vegetation. Oviposition was not observed in nature, but I assume females deposit eggs on the plant. On the islands of Sao Miguel, Faial and Flores, I observed the flight of the butterflies by and large ceased after 1800 hours.

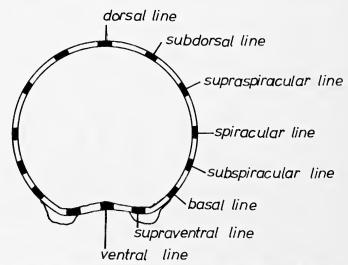


Fig. 2. Description of the lines on the larva body after Shirouzu & Hara, 1979.

## Parasitoides and Predators

No evidence of parasitoides were found from the approximately thirty larvae collected on Faial island. It is not known whether the eggs are subject to parasitism. Walker (1931) described some imagines from the Pico island as having parts of the wings bitten off, and assumed that the bites were caused by Serinus canaria (Linnaeus, 1738). It would appear that Motacilla cinerea patriciae (Vavrie, 1957) could use H. azorina as their diet includes insects. Predators as Lacerta spec. do not occur in the habitats of the H. azorina complex. There are not sufficient data at present to make judgments on the role of either predation or parasitization in regulating the populations of these butterflies.

## Protection of the Species

On all of the Azores islands the intensive use of land for pasture is of great economic importance to local agricultural production. As a result large areas of naturally growing fescue grass vegetation are often broken up by bulldozers in order to be replanted with pasture grasses for higher productivity. The Azores Hipparchia species cannot, however, live in these cultivated pastures. It is reasonable to assume that in the middle of the 15th century, when the Azores were first colonized, that the islands were covered to a great extent with woods. The present environment of the Hipparchia populations on the islands can be seen as secondarily arising after the initial clearing of the woods by the early settlers. As a result, Festuca jubata was probably able to strongly expand, and the Hipparchia populations during that period found a still better environment. Through today's methods of agriculture, this development is regressing, and the pasture environment is now being supplanted by artificially selected grasses for agricultural reasons.

An extensive use of pasture of the natural fescue grasses, as has always been done in the past, did not harm the prospering of the *Hipparchia* population. The method best suited for the conservation of the butterflies is the conservation of initially produced native pasture habitats, most appropriate biotopes being those with a southern to southeastern exposure. The most suitable habitats on Sao Miguel are Gafanhoto, 715 m, and the regions near Pico da Vara. On Faial island the slopes of Pico Gorda and the Caldeira fit the described conditions, and on Flores the best areas are the slopes of Pico dos Sete Pes. For the islands of Sao Jorge and Pico there are no data available yet that species habitats require protection. In any case, care should be taken that such habitats are not allowed to become afforested with *Cryptomeria japonica* (L.F.) D. Don., which is employed in the Azores.

## Conclusions

1. Comparative investigations of morphology of adults and particularly,

of the early stages, provided the basis for a revision of the taxa of *Hipparchia azorina* complex.

- 2. *H. azorina* Strecker 1899 is present only on the central group of the Azores. The type locality is restricted to Pico island. *H. azorina ohshimai* comb. nov. stat. nov. inhabit Faial island, on Sao Jorge one finds *H. azorina jorgense* ssp. n.
- 3. H. miguelensis LeCerf 1935 stat. rev. comb. nov. inhabits Sao Miguel island.
  - 4. H. caldeirense sp. n. inhabit Flores island.
- 5. The habitat of the populations from Sao Miguel, Faial and Flores identified of the *Festuca jubata* zone. The foodplant of the larva is *Festuca jubata* Lowe., although record of the foodplants on Sao Jorge and Pico has yet to be brought forth.
- 6. All populations are monovoltine, hibernation taking place during the larva stage.
- 7. The continuing expansion of the area devoted to modern agricultural production necessitates protection of the species.

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After the completion of this work in May 1982, *Hipparchia* specimens from the Azores were sent to the following addresses: Allyn Museum of Entomology, Sarasota, Florida, U.S.A.; Mr. W. L. Blom†, Groningen, NL; Dr. O. Kudrna, Bonn; Prof. Dr. C. Naumann, Bielefeld; and W. Schmidt-Koehl, Saarbrucken, the remainder are in my collection.

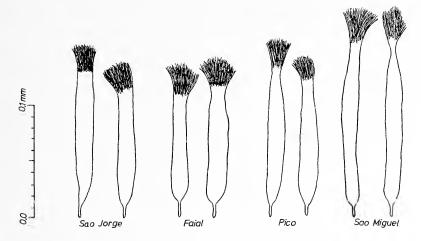


Fig. 3. Androconial scales of the Azores Hipparchia taxa: Sao Jorge: Hipparchia azorina jorgense; Faial: Hipparchia azorina ohshimai; Pico: Hipparchia azorina; Sao Miguel: Hipparchia miguelensis.

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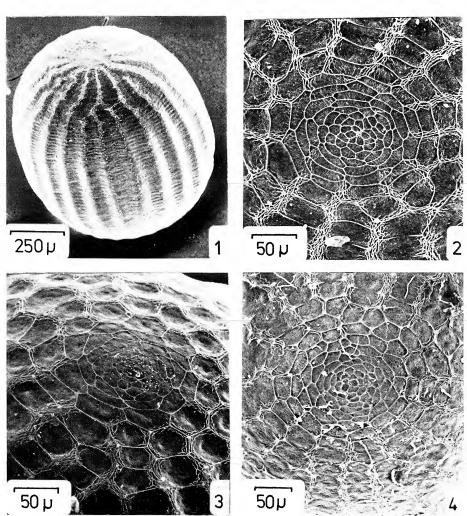


Fig. 4. Eggshells of the Azores Hipparchia taxa,  $1\pm 2$ : Hipparchia azorina ohshimai, 3: Hipparchia caldeirense, Hipparchia miguelensis.

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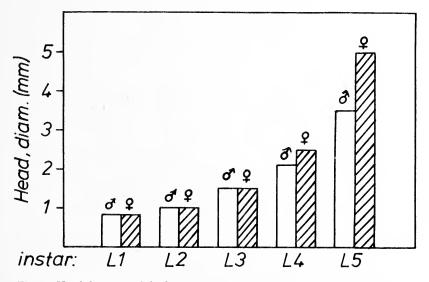


Fig. 5. Head diameter of the larva.

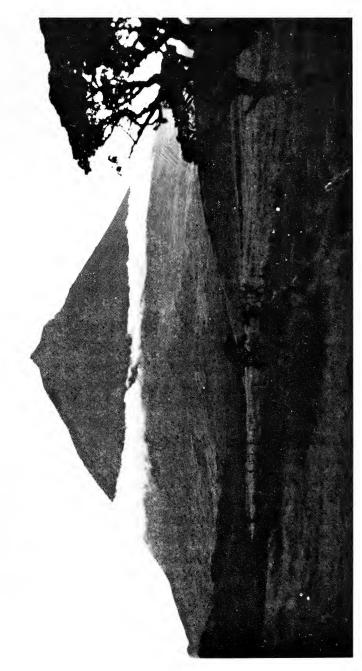
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Fig. 6. Male genitalia. 1. Hipparchia caldeirense, 2. Hipparchia miguelensis, 3. Hipparchia azorina ohshimai, 4. Hipparchia azorina, 5. Hipparchia azorina jorgense, 6. Holotype.



Fig. 7. Female genitalia. 1. Hipparchia caldeirense, 2. Hipparchia miguelensis, 3. Hipparchia azorina ohshimai, 4. Hipparchia azorina jorgense.



Pico island, north side, view from Lagoa do Capitao  $800 \, \mathrm{m}$ , to the Pico  $2351 \, \mathrm{m}$ , only single males of H. azorina were observed on this high plateau. Fig. 8.

# Courtship Behavior of the Dainty Sulfur Butterfly, Nathalis iole with a Description of a New, Faculative Male Display (Pieridae)

Ronald L. Rutowski

Department of Zoology, Arizona State University, Tempe, AZ 85287

Abstract. The components and temporal structure of courtship leading to copulation are described for the dainty sulfur, Nathalis iole (Boisduval). Most successful courtships were similar to those described in the literature for several other pierids. However, in 22% of the successful courtships the male performed a previously undescribed wing spread display in which he alit in front of and facing away from a perched female and assumed a stationary posture with his wings fully spread. This display is elicited by the performance of initial rejection responses by the female. The proximate and ultimate causes of this faculative male display are discussed.

## Introduction

In butterflies, male courtship behavior is viewed as having evolved in response to mate choice by females to insure sex and species identity, and quality of a potential mate (Scott, 1972; Silberglied, 1977; Rutowski, 1982). Because errors in the selection of mates can have severe negative effects on a female's reproductive success, it is expected that all males successful in courtship should be required by females to produce basically similar performances. While collecting data for another study, observations on the courtship of the dainty sulfur, Nathalis iole Boisduval, revealed the existence of a male display that had heretofore been undescribed and surprisingly was not performed in all successful courtships. This report describes the courtship of N. iole with an emphasis on this new display and the contexts in which the display occurs in the hope of discovering something of its proximate and ultimate functions.

## Methods

The dainty sulfur was studied at the Archbold Biological Station 13 south of Lake Placid, Florida, from July to November, 1981. There it flies all year and is most common where *Bidens pilosa* Powell and Turner, its larval foodplant and an adult nectar source, is abundant.

Virgin females were obtained by rearing from eggs. The eggs were collected on sprigs of B. pilosa that had been placed in small (8 x 8 x 8 cm) wire cages with field-caught females. The cages were placed outside in full

sun to induce females to oviposit. The larvae were fed on fresh cuttings of *B. pilosa* in a laboratory where the light-dark regimen and humidity were variable and the temperature ranged from 27-29°C.

To observe courtship behavior, particularly that which preceded copulation, virgin females that varied in age from freshly emerged to no more than 3 days of age were released near free-flying males in the field. (Females not used on day of emergence were stored at 4°C after their wings hardened until use.) Durations of courtships leading to copulation were measured with a stopwatch and represent the time from when the male first arrived (within 2 cm of the female) until the pair had coupled and the male stopped moving. Written records of the sequence of events observed were also made. I especially noted (1) whether the female was flying or perched when the male first approached, (2) whether the female performed a flutter response or mate refusal posture when alighted, (3) whether the male performed a wing spread display, (4) any perch changes by the female after alighting, and (5) whether the male had his wings spread when attempting copulation. When the wing spread display was observed the relative positions of the male and female were noted. Details on the criteria used to judge the occurrence of these behavior patterns are given in "Results."

Courtships staged within outdoor cages were recorded on film using techniques described by Rutowski (1978 and 1979). In spite of numerous attempts, I was not successful at recording a wing spread display on motion picture film, hence detailed information on its temporal structure was not acquired.

In both the field and the cages, mating pairs were separated within a minute of coupling so that the female could be used again in observations of successful courtship. Normal copulation lasts about 15 to 20 min. Throughout this report "virgin female" refers, in addition to the obvious, to females that have been previously but briefly coupled with a male.

Throughout the paper parametric summary statistics will be presented as: mean  $\pm$  one standard deviation (sample size). The 0.05 level was used in making all decisions regarding statistical significance.

## Results

## A. Field Observations: Components of Successful Courtship

Fifty-four successful courtships (= leading to copulation) were observed in the course of releasing 33 virgin females near males in the field. In the descriptions and data that follow no female accounts for more than 3 successful courtships. The most typical sequence of events was as follows.

After release and while still flying, the female was approached by the male. The female then dropped quickly to the ground and alit on a leaf, grass blade, or the soil. While the female sought out a perch the male either followed her closely or, in some cases, hovered about 10 to 20 cm over the female. Once the female had perched, she did not move except to extend

observed (Table 1).

The frequency of occurrence of various types of N. iole courtships among the 54 successful courtships

		Copulation	Wing	Percent	
Female initially	Rejection response	attempt with wing spread	spread display	of all courtships	Duration (sec) $[X \pm SD (n)]$
Perched				12	5.33 ± 1.63 (6)
			+	ъ	$13.66 \pm 6.11 (3)$
	•	+	•	11	$5.20 \pm 1.48$ (5)
		+	+	0	l
	+			11**	$9.16 \pm 4.75 (6)$
	+		+	**6	$13.60 \pm 6.43$ (5)
	+	+		**	$9.00 \pm 1.41 (2)$
	+	+	+	2	13 (1)
Flying	•	,		24	$9.70 \pm 5.29 (10)$
		•	+	0	1
		+	,	<b>[-</b>	$14.30 \pm 6.13 (4)$
	•	+	+	2	24 (4)
	+		,	4**	$14.50 \pm 0.71 (2)$
	+		+	4	23 (1)
	+	+	•	4	8 (1)
	+	+	+	C	

her abdomen out from between the hindwings. The male quickly alit next to the female and oriented head-to-head and tail-to-tail with the female. He then curled his abdomen toward the female's, and brought his genitalia into contact with hers which marked the beginning of copulation. This sequence of events was observed in 24% of the successful courtships

\*/\*\*Data includes 1 (\*) or 2 (\*\*) courtships in which the female changed perch.

Variations in this basic pattern arose when: (1) the female was already perched when the male approached to within 2 cm, (2) the female performed a flutter response or a mate refusal posture when perched. (3) the male performed a display hereafter referred to as the wing spread display, and/or (4) the male attempted copulation with his wings noticeably spread to an angle of about 120-150 degrees. The frequency of occurrence of courtships with these components is given in Table 1. A flutter response (Obara and Hidaka, 1964) was recorded any time a perched female performed at least one wing flick = a rapid opening and closing of the wings (Rutowski, 1978)] while the male courted her. The mate refusal posture (Obara, 1964) was recorded when, in response to the male's presence, a female assumed a posture with her wings spread and her abdomen raised so that its long axis stood perpendicular to the plane of the female's wings. Rarely (n = 7), females changed their perch after alighting by resuming flight. In subsequent analyses these perch changes were grouped with the flutter response and mate refusal postures as initial rejection responses. The data reveal that perched females were no more likely to perform rejection responses than flying females ( $\times$  2 = 2.68, 1df, p < 0.1).

The wing spread display of the male (Fig. 1) was recorded when, after the female had perched, he alit facing away from the female but no more than 3 cm in front of her. Once on the substrate, the male spread his wings and held them fully opened for several seconds during which time the wings quivered slightly. Also, during the time the wings were spread the forewings were held a little forward of and above the hindwings, enough to clearly expose the red-orange sex brand on the dorsal surface of the male's hindwing (Klots, 1951). Wing spread displays were performed in 22% of the observed courtships. They were also observed in some unsuccessful courtships. In some but not all courtships without the wing spread display, the female alit on a vertical grass blade, in dense vegetation, or in some other location that made it impossible for the male to perform a wing spread display due to the lack of suitable substrate. However, it was not possible to quantify the frequency of this occurrence because of difficulty in establishing exactly what constitutes suitable substrate for a wing spread display.

Whether the female is initially flying or perched has no effect on the likelihood that the male will perform a wing spread display (Table 1). Thirty percent of the perched females and 12.5% of those flying when intially approached by males, were courted with wing spread displays. The difference was not significant ( $\chi^2 = 2.36$ , 1 df, p = 0.12). However, if the female performed a rejection response (includes perch changes by female during courtship), a male was significantly and almost 4 times more likely to perform a wing spread display. Of the rejecting females, 40% elicited wing spread displays from the courting males; of females that did not, only



Fig. 1. Courtship behavior in the dainty sulfur, Nathalis iole. The male (wing span  $\sim 2.3$  cm) has landed in front of and facing away from the female and is performing the wing spread display. This figure was drawn from a 35 mm photograph.

10.8% elicited the display ( $\chi^2 = 5.81, 1$  df, p = 0.02). The performance of a wing spread display had no effect on the likelihood that a male would subsequently attempt copulation with his wings spread ( $\chi^2 = 1.24$ , p = 0.26). Males that were accepted in copulation by females were examined and assessed with respect to forewing length and wing wear. Males that performed wing spread displays were not different from those that did with respect to these two characters. Virtually all males were in fresh condition (more than 80% in both groups) and had forewing lengths (base to wing tip) of 14 mm [males that performed wing spread display:  $14 \pm 1$  mm (9); those that did not:  $13.8 \pm 0.62$  mm (34)].

## B. Field Observations: Temporal Structure of Successful Courtship

Table 1 shows that the duration of successful courtship in  $N.\ iole$  is affected by its form. Initial observations indicated that the position of the male's wings (spread or not spread) during copulation attempt had no effect on the duration of the courtship. To test this hypothesis, I compared courtships that varied with respect to the male's wing position during copulation attempt but in which the female did not perform a rejection response, was initially perched and remained so, and was not courted with a wing spread display. The duration of courtships in which the male did not spread his wings during the copulation attempt [5.33  $\pm$  1.63 sec (6)] was not significantly longer than those in which the male did spread his wings [5.2  $\pm$  1.48 sec (5); t = 0.14, 9 df, p = 0.45]. In all analyses presented below, data for courtship with and without this male behavior pattern were pooled.

As a baseline duration I used the mean duration of successful courthsips in which the female (1) was intially perched, (2) performed no rejection responses, and (3) was not courted with a wing spread display. This baseline duration was  $5.27\pm1.49$  sec (11) and was used to study the effect of variation in form on the duration of courtship. When the female was initially flying but did not perform a rejection response and was not courted with a wing spread display, the duration of courtship [11  $\pm$  5.71 sec (14)] was significantly longer than the baseline duration (t = 3.23, 23 df, p = 0.002). Females flew for about 5 to 6 sec on the average before alighting if not perched when the male first approached.

If an initially perched female performed a rejection response but was not courted with a wing spread display, the duration of courtship [9.13  $\pm$  4.05 sec (8)] was significantly longer than the baseline (t = 2.92, 17 df, p = 0.005). This was also true if one eliminates from successful courthsips with a rejection response those in which the female changed perch after the male's approach. Although the mean duration of this group was a little shorter [7.8  $\pm$  4.27 sec (5)] these courtships were still significantly longer than those without a flutter response or mate refusal posture (t = 1.8, 14 df, p = 0.047). Hence, rejection responses typically increased the duration of courtship by a factor of  $1\frac{1}{2}$  to 2.

Male wing spread display also increased the duration of successful courtship. Courtships identical to the baseline courtships, but including male wing spread display had a mean duration of  $13.6\pm6.11$  sec (3), which was significantly longer than the baseline duration (t = 4.5, 12 df, p = 0.001). These data indicate that the wing spread display has an average duration of about 8 sec.

#### C. Film Records

Using 7 lab-reared virgin females, I recorded 16 successful courtships on motion picture film. In the film records, all females were initially perched

(an artifact of the techniques used) but none were courted with wing spread displays. Females performed flutter responses or mate refusal postures in half of the successful courtships recorded. Restrictions on camera movement prohibited the recording of courtships in which the female flew to a new perch. Only 14 of the courtships recorded were complete; all of the analyses that follow are based on information from these 14.

The mean duration of all courtships was  $5.03 \pm 3.64$  sec (14). However, unlike the situation in the field, the duration of courtship without rejection responses [3.93  $\pm$  3.13 sec (8)] was not significantly shorter than that for courtships with rejection responses [6.07  $\pm$  4.01 sec (6); t = -1.125, 12 df, p = 0.14]. In spite of this difference between field and cage courtships the film records generally confirm the accuracy of the field measurements. Courtships recorded on film without rejection responses by females were identical in form to the baseline courtships and were not significantly different from them in duration (t = 1.24, 17 df, p = 0.12). Similarly, courtships recorded on film with rejection responses by females were not significantly different in duration from those of identical form measured in the field (t = 0.425, 8 df, p = 0.34). However, in both comparisons the difference was in the direction of the film records yielding shorter durations than the field records. This is to be expected in light of the inaccuracies inherent in timing such rapid events with a stopwatch.

In these 16 courtships males showed no preference in the side of the female from which they attempted and achieved copulation (male to female's right: 6 courtships; male to female's left: 10 courtships;  $\chi^2 = 1.0, 1 \text{ f}, p = 0.32$ ).

## Discussion

Over 70% of the successful N. iole courtships observed during the field portion of this study and all courtships recorded on film were basically similar in temporal and sequential structure to that described for several other pierids (Peterson and Tenow, 1954; Rutowski, 1978, 1979; Silberglied and Taylor, 1978; Suzuki, 1977). These courtships were characterized as rapid affairs, lasting a few seconds, in which the male buffets the female with his wings and body, the female extends her abdomen in response, and the male then alights and attempts copulation. However, in the other 22% of the successful courtships reported here, the male behaved in a way that has not been previously described for any pierid; he assumed a stationary posture in front of the female with his wings spread. Because such a display is so different from any prior observation and because it is a facultative part of successful courtship, questions immediately arise concerning its proximate and ultimate functions.

The proximate function of the display appears to be to provide the female with information about the male not garnered by her during the

intial phases of courtship. An initial rejection response by a female increases the likelihood that the male will perform a wing spread display. Both the rejection response and the display almost double the duration of courtship over what it is without them. Hence, females that perform rejection responses gain time and a display with which to make a more complete assessment of a potential mate. The exact nature of the signals involved in this assessment are not known but could involve visual signals including the lack of ultraviolet reflectance and the black bar on the dorsal forewing (Rutowski, 1977), and/or chemical signals that probably arise from the male's sex brand on the dorsal hindwing (Vetter and Rutowski, 1978).

What information is the female gathering about the male during the display? It seems most likely that the female is assessing the male's (1) sexual identity, (2) species identity, and/or (3) quality as a mate relative to other conspecific males. Both female and male pierids are known to approach and chase conspecifics on occasion (Rutowski, 1980; Rutowski et al., 1981). Several observations were made during this study of N. iole females engaging in such behavior. The wing spread display may be a way for females to confirm the sex of the courting animal by the performance of the display and by visual and chemical signals enhanced by the display. Information about the species identity of a courting male may also be important to the female in that N. iole is sympatric over a large part of its range with Eurema daira Godart and E. lisa Boisduval and LeConte, two species of small sulfurs closely related and visually and behaviorally similar to N. iole (Rutowski, 1977, 1978). Again, the display may provide visual, chemical, and behavioral confirmation of a male's species identity. Finally, the display may provide the female with information about the male's age, size, persistence, or other characteristics that could be indicative of his overall genetic quality and ability to invest in the female's offspring. Male butterflies are known to pass nutrients to the female during copulation that she may use in oogenesis (Boggs, 1981; Boggs and Gilbert, 1979; Boggs and Watt, 1981). Rutowski (1982) has reviewed the Lepidoptera for some of the characteristics of males that may be important in selection among conspecific males by females.

In summary, the male display appears to have evolved as a way of delivering information to females who are initially unreceptive. Exactly which portion of the information presented to the female by the display is most important to her is as yet unclear. However, by comparing the behavior of N. iole with that of its sympatric and very similar relatives E. lisa (Rutowski, 1978) and E. daira (unpubl. data) it may be possible to evaluate the three hypotheses about its ultimate function proposed in the previous paragraph.

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# On the Supernumerary Chromosomes of Tarache tropica Guen. (Lepidoptera: Noctuidae)

P. K. Mohanty

and

B. Nayak

Department of Zoology, F. M. College, Balasore 756 001, Orissa, INDIA

Abstract. The karyotype of *Tarache tropica* Guen. consists of 1 to 7 minute dot-shaped supernumerary chromosomes in addition to the normal haploid complement, n=31. The exact nature of the accessory chromosomes, whether they are true supernumeraries or are the unpaired nonhomologous elements produced through interspecific hybridization, is not clear, though the latter explanation appears to be more probable.

## Introduction

Many species of plants and animals show one or more supernumerary chromosomes, characteristically different from ordinary chromosomes in their karyotype (Wilson, 1925; White, 1973; Jones, 1975). In Lepidoptera, however, reports on the number of species showing such elements are rather scanty (Dederer, 1928; Beliajeff, 1930; Federley, 1938; Lorkovic, 1941; Maeki, 1953; de Lesse, 1960a; Bigger, 1976; Rao and Murty, 1976; Nayak, 1978). Indeed, it is difficult to distinguish genuine B-chromosomes since the lepidopteran karyotype often includes a large number of small dot-like compact chromosomes which yield very little information about their exact morphology. An attempt has been made here to analyze the nature of such supernumerary elements in the karyotype of *Tarache tropica*, a species cytologically investigated for the first time.

#### Material and Methods

The larvae of *Tarache tropica* were collected from their host plant (unidentified) in the close vicinity of Bhubaneswar during July-August, 1976. These were reared in cages in the laboratory. The mature male larvae (5th instar) and early pupae provided suitable testes material for the study of spermatocytic chromosomes. Temporary preparation of the material using Bellings' acetocaramine was tried. For permanent preparation, the larval sexual organs were dissected in a colchicine-hypotonic solution (0.01% Colchicine in 0.45% of Sodium Citrate solution), followed by washing in fresh hypotonic solution for 30-40 minutes at room temperature. The testis was then transferred to a slide which was slightly

tipped to remove the hypotonic solution completely. The material was then torn into pieces in a drop of 60% aceto-ethanol (1:3) fixative and then squashed. The slide was next placed in a freezing chamber of a freezer for 2-3 minutes and the cover glass removed with care using a razor blade. The frozen preparation was then subjected to gently blowing air over it. The slide was then transferred to absolute glacial acetic acid for ½ to 1 minute to remove cytoplasmic staining and the slide was again air dried. The preparation was stained with Giemsa, diluted about 50 times in Sorensens' phosphate buffer (pH 7) for 8-10 minutes at room temperature.

## **Observations**

The diploid chromsomes, as revealed in some of the spermatogonial metaphase stages of T. tropica, were 2n=62. The individual chromosomes were dot-like, almost isodiametric and compact bodies vielding no information regarding the position of the centromere. Morphologically, the gonial chromosomes were not differentiable into sex-chromosomes and autosomes. The haploid chromosome number as established from a count of pro-metaphase or metaphase I chromosomes was n=31. Metaphase I bivalents appeared oval in a polar view and dumbbell-shaped in a equatorial view. Late diakinesis or pro-metaphase plates and metaphase I cells of different specimens when compared showed variation in chromosome numbers from specimen to specimen and from follicle to follicle of the same individual. In addition to the normal karvotype of n=31 bivalents, a variable number of minute chromosomal elements, much smaller than the normal bivalents, was encountered. The uneven distribution, irregular number, and minute size all indicated that they were not homologous to any of the members of the karyotype. They appeared to be univalents without any homologous partner. In 6 of the 21 individuals investigated, only one supernumerary element was observed in the karyotype. In five of these, the supernumerary chromosome was stable and was observed in every meiocyte, while in the sixth, some (possibly of one cyst) had single m-chromosome each which was not seen in the remainder. Metaphase II plates were rare. The m-chromosome frequency in other specimens was high, 3 to 7 elements were encountered at metaphase I. They were smaller than the regular chromosomes and showed irregular segregation at first anaphase. The exact nature of these minute elements, whether they are supernumeraries or are unpaired elements due to interspecific hybridization, is not clear. However, their uneven distribution indicates their supernumerary nature.

#### Discussion

In the absence of direct evidence, the origin of supernumeraries is highly enigmatic. White (1973) assumes their origin to be through fragmentation of heterochromatic blocks of normal chromosomes. Robinson (1971), as



Fig. 1. Spermatogonial mitosis showing 62 dot-like elements.

Fig. 2. Metaphase I showing 31 bivalents and 7 extra elements of supernumerary nature.

Fig. 3. Metaphase I with 3 m-chromosomes.

well, holds them to be small segments of normal chromosomes undergoing accidental breakage and showing erratic meiotic behaviour due to their acentric nature. In Lepidoptera, where fragmentation is a common aspect of chromosome evolution, Robinson speculates that the occurrence of supernumeraries is no doubt a special case where an element is produced which behaves differently from a chromosome which has fragmented into two stable bodies, each of which behaves sufficiently normal to become a part of the karyotype. Jones (1975) is of the opinion that sex-chromosomes, particularly the X-chromosomes, are very likely the ancestors of microchromosomes. Bigger (1976) observed the karyotype of two British Pieris species to be identical in cells with and without B-chromosomes. Based on this observation, he concludes that supernumeraries are true additional chromosomes and not small fragments of the normal karyotype, as hypothesized by White (1973) and Robinson (1971). We agree with the last two authors that numerical variation may arise due either to accidental breakage of normal chromosomes or mixing of chromosomes from different nuclei. In the present case of Tarache tropica, the occurrence of 1 to 7 supernumeraries may well be due to interspecific hybridization in nature and may therefore present non-homologous unpaired univalents. Rao and Murty (1976) hypothesize that B-chromosomes confer an advantage on the population. This may not be true at least in the case of Tarache tropica, since a variable number of such supernumeraries occur in different follicles of the same individual, as well as in follicles of different individuals at the same time.

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# An Apparent Interspecific F<sub>1</sub> Hybrid Speyeria (Nymphalidae)

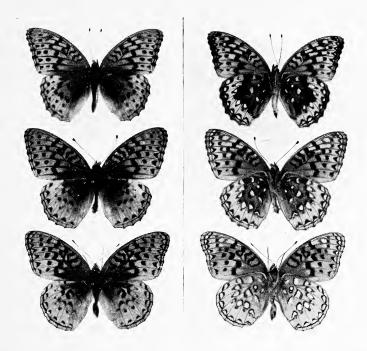
James A. Scott

60 Estes Street, Lakewood, Colorado 80226

An apparent male F<sub>1</sub> hybrid (Figs. 3-4) was captured in a wet meadow near Bridgeport, Mono County, California, August 25, 1974. It is intermediate between *Speyeria (Speyeria) nokomis apacheana* (Skinner) (Fgs. 5-6) and S. (Semnopsyche) cybele leto (Behr) (Figs. 1-2). Pure populations of both species were caught there August 7, and the hybrid and nokomis were caught August 25.

The hybrid male may be characterized phenotypically as follows: dorsally, 1)postmedian HW black spots in cells M3 and Cu1 are intermediate in shape (nokomis has the spots shaped like ¼ moons, leto's are much thicker), and 2) there is a normal sized spot and a small spot at end of DHW cell (nokomis has two normal sized spots, leto only one spot). Ventrally, 3) hindwing disk and margin is light brown (the disc and margin are yelow in apacheana, dark brown in leto), 4) silver spots are intermediate in shape (round in nokomis, more crescentic in leto), 5) submarginal cones of dark scales on HW and FW are partly brown and partly black (cones are black in nokomis, brown in leto), 6) FW red flush is intermediate in extent (flush covers most of the wing in nokomis, only half of wing in leto), and 7) postmedian dots on FW near apex are partly black and partly brown (dots are black often edged with green in nokomis, brown in leto).

These characters (except 1 and 4) are very different in the two species; they are clearly intermediate in the hybrid, suggesting that it is an F<sub>1</sub>. It is the first hybrid described in the genus, although Paul Hammond (pers. comm.) has a natural female hybrid S. cybele pugetensis C. & F. X S. hydaspe rhodope (Edw.). Both hybrids are between different subgenera. The subgenus Semnopsyche is based on only one character, the female bursa copulatrix (dos Passos & Grey, 1945, 1947). Modern systematic theory emphasizes the use of many characters delineating taxa (Wiley, 1981). S. cybele leto and nokomis are similar in wing pattern, although they are somewhat different in gene frequencies of some adult body enzymes (Brittnacher et al., 1978). The heterogametic (XY) sex (the female in Lepidoptera) is less often represented in interspecific crosses in Lepidoptera in general. The occurrence of both male and female hybrids, and their occurrence between species previously thought to be in separate subgenera,



Figs. 1-6. S. cybele leto, top row (Fig. 1 left, Fig. 2 right);
S. cybele leto X S. nokomis apacheana, middle row (Fig. 3 left, Fig. 4 right);
S. nokomis apacheana, bottom row (Fig. 5 left, Fig. 6 right).

Left column upperside, right column underside.

suggests that hybridization may be fairly frequent in *Speyeria*, but hidden by the difficulty of identifying many similar species.

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# A New Record of Vanessa virginiensis "ab. ahwashtee" from Northern California (Lepidoptera: Nymphalidae)

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Arthur M. Shapiro

Department of Zoology, University of California, Davis, California 95616

**Abstract.** A new record of *Vanessa virginiensis* "ab. *ahwashtee*" is presented from Nevada County, California. The occurrence and biological significance of this and related aberrations in *Vanessa* are reviewed.

The study of aberrant wing-patterns in butterflies is currently undergoing a mild renaissance, after being cast into disrepute for decades by the nomenclatorial excesses of some European workers. Although treated by Field (1971) with disdain, the "elymi" series of aberrations in the genus Vanessa hold great biological interest because parallel and probably homologous aberrant phenotypes occur repeatedly in at least five species, belonging to two subgenera. They probably represent the classic phenocopy situation, in which the same aberrant phenotype may be produced by a mutant gene in normal environments, or by abnormal environments acting on a normal genotype (Shapiro, 1976). Aberrations of this series have received names (of no standing in formal zoological nomenclature) in V. cardui L., V. atalanta L., V. annabella Field, and V. virginiensis Drury. They also occur in the South American V. carye Hbn. sens. str. (J. Herrera, personal communication).

The "letcheri - muelleri" aberrations of the "elymi" series are readily inducible in V. annabella by cold shock applied to the pupa (Dimock, 1968; Shapiro, 1976 and unpublished). "Elymi" itself is more difficult to induce in V. cardui, and most specimens are only moderately modified by cold (Shapiro, 1975). The corresponding phenotype "ahwashtee" has not been induced in V. virginiensis in over 100 trials with cold shock since 1972 (Shapiro, unpublished). Both this species and V. atalanta seem better buffered against cold shock than the others, though European workers have successfully manipulated V. atalanta with both heat and cold.

On 28 June 1981 a fresh, perfect male *V. virginiensis* "ab. ahwashtee" was collected by the author at Lang Crossing of the South Yuba River, Nevada County, California, on the west slope of the Sierra Nevada at about 1500 m. Two normal individuals were seen in the same clump of flowering *Agastache nepetoides* (Labiatae). The capture was verified at the scene by Mr. Marc Minno and Ms. Jennie Dusheck. The specimen (Figs. 1, 2) is very similar to the original "ahwashtee" figured by Comstock (1927,

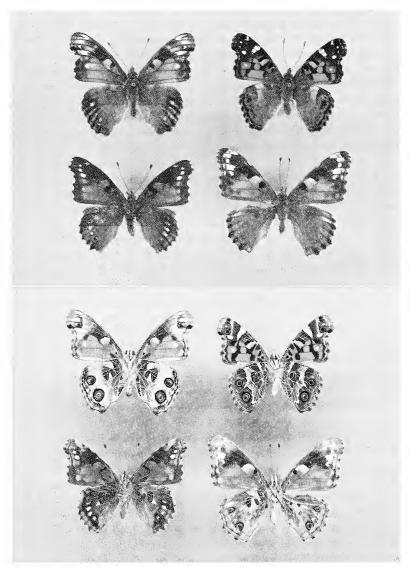


Fig. 1. Dorsal surfaces of Vanessa. Upper right: bred V. virginiensis, normal. Upper left: V. virginiensis ab. "ahwashtee", Sierra Nevada, CA, 28 June 198. Lower right: V. cardui, "elymi"-like aberration induced by pupal chilling. Lower left: V. annabella, "muelleri"-like aberration induced by pupal chilling.

Fig. 2. Same, ventral surfaces.

pl. 42, fig. 6). The bibliographic history of this name is traced by Field (1971, p. 48). I have been unable to locate any new records of "ahwashtee" in the past 40 years, and it is not included in recent reviews of the "elymi" series (Shapiro, 1973, 1975; Phillips, 1971). The apparent rarity of aberrations in *V. virginiensis* parallels the strong pattern canalization observed in the laboratory and does not seem to be an artifact of its more restricted distribution and localized abundance as compared to *V. annabella* and *V. carye*. It is often the commonest *Vanessa* at high elevations and I have seen several thousand California examples in the past decade without ever noting a major aberration before.

The cause—genetic or environmental—of "ahwashtee" remains problematical, but the Nevada County example coincides with unusual weather events. From 11 through 13 June 1981 there were nightly severe freezes at Lang Crossing, with lows down to -5°C (and highs of 15°C). These freezes were sufficient to kill much of the year's growth of two particularly sensitive plants, bracken (*Pteridium aquilinum*, Polypodiaceae) and tall knotweed (*Polygonum phytolaccaefolium*, Polygonaceae) at Lang. The weather then warmed rapidly to daily highs and lows of about 25-27° and 7°. If the 28 June animal was indeed fresh, it would probably have been a young pupa about 11 June, and the young (8-12 hr old) pupa is known to display maximum temperature sensitivity in laboratory experiments. An attempt to duplicate these conditions will be made when material becomes available.

Because the "elymi" series of aberrations holds such interest for both developmental and evolutionary biologists, new records should be published, preferably with a photograph, and female examples should be bred from whenever possible. Perhaps the study of aberrations can be resumed without the absurd multiplication of names, misrepresentation of reared as wild examples, and stamp-collector competition which removed it from biology earlier in this century; one may hope so.

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# The Colonization of Violets and Speyeria Butterflies on the Ash-Pumice Fields Deposited by Cascadian Volcanoes

Paul C. Hammond

2435 East Applegate, Philomath, Oregon 97370

Abstract. Violently explosive eruptions from the volcanoes of the Cascade Range have deposited extensive ash-pumice fields that constitute an extremely xeric habitat for most types of plants and animals. This study examines the colonization of this habitat by nymphalid butterflies of the genus Speyeria together with their larval foodplants of the genus Viola (Violaceae). Study areas include ash fields associated with Mt. Washington, the Three Sisters volcano system, Mt. Newberry, Mt. Mazama, Mt. McLoughlin, and Mt. Shasta in Oregon and California. Some species of Speyeria and Viola have proven to be vigorous colonizers of the ash-pumice habitat, while other species have been completely excluded from this habitat due to restrictive limitations in their physiology and ecological adaptations. Successful colonizing species have invaded the ash fields from several different directions: (1.) adjacent regions of the high Cascades, (2.) the arid lowlands east of the Cascade Range, and (3.) the Sierra Nevada and Siskiyou Mountains south and west of the Cascades. These organisms demonstrate how plants and associated insects may colonize and adapt to new habitats created by volcanic eruptions in the Cascade Range.

### Introduction

The nymphalid butterflies of the genus Speyeria are intimate associates of the herbaceous plant genus Viola (Violaceae), since the larvae of Speyeria feed exclusively upon the leaves and flowers of Viola. Together these plants and animals are widely distributed throughout much of North America, and are among the most ecologically versatile of organisms in terms of the diversity of habitats that they occupy. These habitats range from dense forests to open prairies; permanently wet bogs to arid deserts. In addition, violets and Speyeria butterflies are usually very sensitive indicator organisms to human-caused disturbances of natural communities. Indeed, many populations of these organisms have become extinct or are threatened with extinction due to human disturbances such as agriculture and suburban development. A good example are the extinctions of Viola hallii Gray and Speyeria callippe Boisduval in the Willamette Valley grasslands of western Oregon about 50 years ago (unpublished data).

One of the most unusual habitats occupied by Viola and Speyeria are the extensive volcanic ash-pumice fields associated with the stratovolcanoes of the Cascade Range. These volcanoes extend from Mt. Garibaldi in southern British Columbia south to Mt. Lassen in northern California. Most of these volcanoes have experienced many violently explosive eruptions of the recent Mt. St. Helens type during their long histories. During such eruptions, vast quantities of finely divided silicaceous ash and pumice are ejected, so that adjacent areas downwind from the volcano are buried under deep layers of this material. The most extensive ash-pumice field was produced by the cataclysmic destruction of Mt. Mazama about 6600 years ago, and covers hundreds of square kilometers in central Oregon extending from Crater Lake in northern Klamath County to the Paulina-East Lakes in southern Deschutes County. Harris (1980) has prepared a general review of the history and geological characteristics of the Cascadian volcanoes.

As the ash-pumice fields are deposited during eruptions, most biological life forms are completely exterminated as a result of burial and suffocation. For example, David V. McCorkle (personal communication) is currently monitoring the recovery of Speyeria populations near Yakima, Washington, following the recent eruption of Mt. St. Helens in May, 1980. Prior to this eruption, large populations of S. callippe and S. coronis Behr were found in the eastern foothills of the Cascades west of Yakima. The Mt. St. Helens eruption was relatively mild compared to many past historical eruptions of other Cascadian volcanoes, and only 6-20 cm. of ash was deposited in the region near Yakima in 1980. Nevertheless, almost no Speyeria were observed in this region during 1981 except for a single specimen of S. coronis. In dramatic contrast, the ash-pumice fields examined in this paper were created by the deposition of several meters of volcanic material (up to 75 meters near Crater lake), which must have virtually sterilized these areas of all pre-existing Viola and Speyeria populations. This paper will examine the probable origins of Viola and Speyeria populations that were able to invade and re-colonize these newly created volcanic habitats, plus the ecological characteristics and adaptations of the organisms to such habitats.

These ash-pumice fields constitute an extremely xeric habitat for plants and animals, since this finely divided volcanic material fails to retain moisture. In areas where the depth of ash exceeds 30 cm., there is very little moisture available to herbaceous plants in the surface soil during the summer growing season, with the exception of the moist areas adjacent to creeks, lake shores, and boggy seepage areas. Most deep ash fields only support a forest of small, shrubby Lodgepole Pine (Pinus contorta Dougl.). The forest floor is mostly barren except for scattered Bitterbrush (Purshia tridentata Pursh) and small tufts of grasses. However, areas with only a shallow layer of surface ash and pumice will support a more substantial

forest of Ponderosa Pine (*Pinus ponderosa* Dougl.) or White Fir (*Abies concolor* Lindl. & Gord.). At the higher elevations, melting snowbanks are an important source of moisture in the spring and early summer, and permit the growth of some herbaceous plants such as lupines (*Lupinus* sp.) and Yellow Prairie Violet (*Viola nuttallii* Pursh.).

## **Methods and Materials**

During the present study, field investigations were conducted on the volcanic ash fields of the Cascades from Mt. Washington in Linn County, Oregon, to Mt. Shasta in Siskiyou County, California, during 1974, 1975, 1980, and 1981. Specific study areas included: (1.) ash fields near Big Lake just north of Mt. Washington in Linn County, (2.) ash fields east of the Three Sisters volcanoes in Deschutes County, (3.) the Mazama-Newberry ash fields extending from Crater Lake eastward to Yamsey Mountain in Klamath County and northward to the Paulina-East Lakes in southern Deschutes County, (4.) ash fields at the summit of the Cascades south of Mt. McLoughlin and Lake-of-the-Woods in southern Jackson and Klamath Counties, and (5.) ash fields around Mt. Shasta in Siskiyou County.

In each study area, the habitat, vegetation type, sun exposure, and the consistency of the ash-pumice soil were noted (Table 1.). Individual violet plants were measured and observed during the course of their growing season, and samples of the associated *Speyeria* species were collected. Measurements included leaf length, total diameter of plants, and butterfly forewing length. The butterflies were also examined with regard to variation in the coloration of the ventral hindwings. In addition to samples of butterflies collected during the present study, older samples collected between 1950 and 1970 were examined in the collections of Ernst J. Dornfeld of Corvallis, Oregon, Oregon State University, and the National Museum of Natural History in Washington, D. C.

## Origin of the Speyeria Butterflies

In order to understand how the violets and butterflies have colonized the ash-pumice fields of the Cascade Range, it is necessary to examine the origin and ecology of these organisms in adjacent non-volcanic regions of Oregon and northern California that have not been exposed to significant volanic activity during the past 50,000 years. In a previous study, Hammond (1974) examined the ecology of *Speyeria* butterflies across North America, and a brief summary of this ecology for the Pacific Northwest *Speyeria* is useful for the present study (see Table 2).

Eight different species of Speyeria are widely sympatric in the mountains through much of the Pacific Northwest from western Montana and Wyoming to the Cascade Range and southward through the Sierra Nevada of California. Although adult butterflies frequently fly together, there is

**Table 1.** Populations of *Viola* and *Speyeria* that have colonized the volcanic ash-pumice fields of the southern Cascade Range.

Volcanoes	Habitat	Viola	Speyeria
Mt. Shasta	Red Fir forest	purpurea	egleis
Mt. McLoughlin	high elevation Lodgepole Pine forest	purpurea, nuttallii	atlantis
	lower elevation mixed conifer forest	purpurea, nuttallii	egleis
Mt. Mazama, Mt. Newberry, Three Sisters	Lodgepole Pine forest	purpurea	egleis, zerene
	moist, open areas	purpurea, nuttallii	callippe, coronis
	wet, boggy meadows	palustris, adunca	mormonia
Mt. Washington	mixed conifer forest	nuttallii, orbiculata	atlantis, hydaspe

**Table 2.** Typical habitats of *Viola* and *Speyeria* species in non-volcanic regions of the Pacific Northwest.

Habitat	Viola	Speyeria
exposed wet meadows	palustris, adunca	mormonia
sheltered wet meadows with thicker of willows, alders, etc.	ts glabella, palustris, adunca	cybele
dry meadows and grassy prairies at high elevations	nuttallii	atlantis
dense, moist spruce-fir and pine forests	glabella, orbiculata, adunca, nuttallii	hydaspe
open, dry pine forests	adunca, nuttallii, purpurea	zerene
exposed, dry rocky ridges and talus slopes at high elevations	purpurea	egleis
sagebrush-juniper communities	nuttallii, purpurea, douglasii, beckwithii	callippe, coronis

usually fairly sharp segregation among species in the types of habitat utilized by the larvae. Each species appears to be adapted for utilizing a particular type of habitat, although Speyeria larvae are not adapted to any particular species of violet and will feed upon any violet that happens to be growing in the appropriate habitat (Hammond, 1974). At the same time, most Speyeria species exhibit considerable ecological plasticity, and frequently invade the habitats of related species when the latter are absent for one reason or another (see contrasts between West Coast and Rocky Mountain S. mormonia, S. atlantis, and S. hydaspe cited below). These observations of such "ecological release" provide indirect evidence that the ecological segregation of Speyeria species is largely the result of interspecific competition for the larval foodplant in the various habitats.

Two species, S. mormonia Boisduval and S. cybele leto Behr, occupy wet, boggy meadow habitats. Speyeria mormonia favors completely open, exposed meadows that are free of shrubs and small trees, while S. cybele leto favors more sheltered meadows with thickets of willows (Salix sp.) and small trees. Another species, S. atlantis dodgei Gunder, also occupies open meadows at the higher elevations in the mountains, but only dry, well-drained meadows in contrast to the boggy meadows occupied by S. mormonia. It should be noted that these relationships change in the Rocky Mountains, where S. mormonia occupies both the dry and wet meadow habitats, while Rocky Mountain subspecies of S. atlantis occupy spruce-fir and aspen forest habitats.

However, the primary forest species in the Pacific Northwest is S. hydaspe Boisduval, which occupies spruce-fir forests at high elevations and dense, moist Ponderosa Pine forests at middle elevations. Speyeria zerene Boisduval is adapted to more xeric conditions and replaces S. hydaspe in very dry, open pine forests. The species also extends out into the highly xeric sagebrush-juniper habitat to some extent as well. Speyeria callippe Boisduval is adapted to the most extreme of xeric habitats, and occupies sagebrush-juniper communities throughout much of western North America at the lower elevations. West of the Cascade and Sierra Nevada Ranges, S. callippe occupies dry, open grassland and oak-pine shrubland at low elevations. At high elevations in the mountains, S. callippe is often replaced in the xeric habitat by S. egleis Behr, which usually occupies barren, exposed rocky ridgetops and talus slopes within the spruce-fir zone. The last species, S. coronis Behr, is another semidesert species like S. callippe, and usually occupies sagebrushjuniper habitats or open, dry pine forests. However, S. coronis is a much larger species than the others, and appears to require a much larger biomass of the larval foodplant (based partly upon observations of reared larvae). Thus, S. coronis is commonly associated with moist areas near creeks, lakes, and seepage areas in these arid regions where the violets produce a more vigorous growth.

# Origin of the Violets

Seven different species of violets provide important larval foodplants for Speyeria butterflies in the Cascade Range (Table 2). Viola palustris L. occupies wet, boggy meadows near creeks, lakes, and seepage areas throughout much of western North America, but only meadows with a permanent source of water. In contrast, V. adunca J. E. Smith var. bellidifolia Greene occupies wet, boggy meadows that dry out during July and August. Both of these violets are very common in wet meadows at high elevations throughout the Oregon Cascades, and are the primary larval foodplants of S. mormonia and S. cybele leto. A third violet, V. nuttallii Pursh. var. linguaefolia Nutt., occupies dry, well-drained meadows and open grassy prairies at high elevations throughout much of western North America, and is the primary larval foodplant of S. atlantis dodgei in the Cascade Range.

Two species of mesic forest violets, V. glabella Nutt. and V. orbiculata Geyer, occupy the moist spruce-fir forests at high elevations and are the primary foodplants of S. hydaspe in the Cascade Range. At lower elevations, the drier Ponderosa Pine forests are occupied by V. nuttallii, V. purpurea Kell., and the typical form of V. adunca J. E. Smith. These violets are utilized by the larvae of both S. hydaspe and S. zerene. Both V. nuttallii and V. purpurea also extend into the sagebrush-juniper zone where they are utilized by S. callippe and S. coronis. In addition, the xerophytic V. purpurea var. venosa S. Wats. occupies exposed, rocky ridgetop and mountainsides at high elevations throughout much of western North America, and is the primary larval foodplant of S. egleis.

However, the most extreme xerophytes among the North American violets belong to the *V. douglasii-beckwithii* species complex. *Viola douglasii* Steudel occupies dry, open grasslands and oak-pine brushland at low elevations in California, extending from northern Baja California north to Medford and Klamath Falls, Oregon. There is also an isolated relict population of *V. douglasii* along the Metolius River in Jefferson County, Oregon. East of the Sierra Nevada and Cascade Ranges, *V. douglasii* is replaced by the closely related *V. beckwithii* Torr. & Gray in the sagebrushjuniper community. Both violets are primary larval foodplants for *S. callippe* and *S. coronis*.

#### Colonization of Mt. Shasta Ash Fields

According to Harris (1980), Mt. Shasta represents one of the largest stratovolcanoes in the world, reaching 4317 meters in elevation. The volcano actually consists of a series of eruptive cones that have been built upon each other. The most recent major cone, Shastina, has only developed during the past 10,000 years and now reaches 3759 meters in elevation. Violently explosive eruptions of massive proportions apparently took place during this period, and pyroclastic flows covered much of the

territory near the base of the volcano. Today the steep upper slopes of Mt. Shasta are covered with glaciers and snow during much of the year. The lower slopes of the mountain are covered with a thick layer of finely divided volcanic ash and pumice that supports a well developed forest of Shasta Red Fir (Abies magnifica A. Murr. var. shastensis Lemmon). A particularly deep ash-pumice field extends to the northeast of Mt. Shasta and only supports a sparse forest of Lodgepole Pine.

The primary violet and *Speyeria* butterfly found on the Mt. Shasta ash fields are *V. purpurea* and *S. egleis* respectively. Both species are very common in the Red Fir forests at the higher elevations on the volcano. The violets grow in the loose ash soil of the forest floor, and even form a thick carpet of plants in some areas of the forest. Adult butterflies fly mostly in sunny glades and clearings within the forest near the violets, and only occasionally stray out into the more open, non-forested areas of the mountain.

This last point is important when considering the origins of S. egleis in the non-volcanic habitats of the Sierra Nevada, Warner, and Salmon-Siskiyou Mountains. In these mountains, V. purpurea is very common in both dry, open Ponderosa Pine forests and on barren, rocky ridgetops and exposed mountainsides. Speyeria zerene usually occupies the pine forest habitat while S. egleis occupies the open, rocky habitat throughout these mountains. Likewise, S. zerene is the dominant species in the open, dry pine forests surrounding Mt. Shasta at the lower elevations. However, the occupation by S. egleis of the Red Fir forests at higher elevations on Mt. Shasta clearly represents a marked ecological shift from the open, rocky habitat of S. egleis in the Sierra Nevada, Warner, and Salmon-Siskiyou Mountains. The reasons for this sharp ecological shift may have the following possible explanation.

Speyeria zerene exhibits a definite preference for relatively warm forests at lower elevations, while S. hydaspe usually occupies cool, moist spruce-fir forests at higher elevations. The failure of S. hydaspe to occupy the Red Fir forests on Mt. Shasta may be due to the extremely xeric nature of the loose ash-pumice soil found on most of Mt. Shasta. Speyeria hydaspe does occur in limited numbers in small stands of particularly dense, moist forest on the lower slopes of Mt. Shasta, so the species does have the opportunity to invade the upper Red Fir forests. Therefore, it would appear that the failure of S. hydaspe to successfully occupy this forest habitat has allowed S. egleis to make the ecological shift into the forest habitat as an opportunistic colonizer. The major part of this colonization probably took place during the past few thousand years following the completion of Mt. Shasta's massive explosive eruptions from the recently built Shastina cone. These S. egleis populations also extend eastward from Mt. Shasta into the Medicine Lake volcano system.

# Colonization of Ash Fields Near Mt. McLoughlin

Extensive ash-pumice fields are also found along the summit of the Cascade Range south of Mt. McLoughlin in southern Jackson County, Oregon, and south of Lake-of-the-Woods in southern Klamath County. These ash fields support either pure forests of Lodgepole Pine or mixed forests of Lodgepole Pine, Ponderosa Pine, and White Fir (Abies concolor). Viola purpurea is still common in this area, but is not so abundant as on Mt. Shasta. Instead, the dominant violet on these ash-pumice fields is V. nuttalli var. linguaefolia, a species that occupies dry open meadows and grassy prairies at high elevations throughout the Cascade Range. In the ash fields near Mt. McLoughlin, both V. purpurea and V. nuttallii often form a dense carpet of plants in the ash soil of open clearings within the pine forest, but the individual plants are usually very small rosettes measuring only 2-6 cm. in diameter.

The primary Speyeria that utilizes V. nuttallii in the high mountain meadows and prairies of the Cascade Range is S. atlantis dodgei, and this species has followed V. nuttallii into the ash-pumice fields south of Mt. McLoughlin. Speyeria atlantis is the dominant species on the ash fields along the summit of the Cascades in Jackson County, although a few S. egleis are also present in this area. However, there is a rapid shift in dominance over to S. egleis on the ash fields south of Lake-of-the-Woods in Klamath County. The reasons for these replacements between S. egleis and S. atlantis are not really known, but are thought to be the result of subtle differences in temperature and moisture in the two areas. For example, the ash fields along the summit of the Cascades are usually covered with a deep snowpack during the winter, while the lower elevations along the eastern slope of the Cascades in Klamath County usually receive much less snowfall.

A very similar situation exists in the central Oregon Cascades. Both *V. purpurea* and *S. egleis* are absent from the summit of the Cascades in the Mt. Washington ash fields of Linn County, but both species are present on the eastern slope near the Metolius River and east of the Three Sisters volcanoes in Jefferson and Deschutes Counties. The ash fields north of Mt. Washington near Big Lake support large populations of *V. nuttallii* just as in the Mt. McLoughlin area, and some *S. atlantis dodgei* are also associated with these violet populations. However, both *V. orbiculata* and *S. hydaspe* have also penetrated into the Lodgepole Pine forests around Mt. Washington from the adjacent spruce-fir forests on Santiam Pass. This is the only instance where a mesic species of violet and *Speyeria* butterfly have been observed to occupy a xeric ash-pumice habitat, and is probably due to the moisture received from the heavy snowpack that accumulates during the winter along the Cascade summit.

# Colonization of the Mt. Mazama-Mt. Newberry Ash Fields

The deepest and most extensive ash-pumice fields in the Oregon

Cascade Range were deposited by massive, violently explosive eruptions from Mt. Mazama and Mt. Newberry in northern Klamath County and southern Deschutes County. These ash fields also extend northward in Deschutes County along the eastern slope of the Three Sisters volcanic system; a complex of numerous volcanoes that have also produced significant eruptions of ash and pumice. The most important eruption was the cataclysmic explosion that destroyed Mt. Mazama about 6600 years ago, creating the modern Crater Lake caldera. Likewise, Mt. Newberry has also been replaced with a deep caldera crater that is occupied by Paulina Lake and East Lake today. The deepest ash fields extend from the south end of Crater Lake National Park eastward to Yamsey Mountain in Klamath County and northward to the Paulina-East Lakes in Deschutes County, an area covering more than 3500 square kilometers. According to Harris (1980), the depth of these ash-pumice fields ranges from 7-15 meters, and reaches a depth of 75 meters in some of the creek valleys near Crater Lake. Before this cataclysmic eruption, Mt. Mazama was one of the largest Cascadian stratovolcanoes, reaching an estimated height of 3660 meters. Afterwards, an estimated 65 cubic kilometers of volcanic material were expelled from the mountain to produce these ash-pumice fields. The Newberry caldera is thought to have been created through a series of violently explosive eruptions according to Harris, rather than in a single cataclysmic eruption as with Mt. Mazama. The most recent eruptions are thought to have taken place less than 1000 years ago. As Harris has pointed out, Mt. Newberry is a huge shield volcano extending 32 kilometers in diameter with some 200 parasitic cinder cones on the slopes of the volcano. In addition to explosive eruptions of ash and pumice, the volcano has also produced numerous thicker flows of basalt and obsidian during the course of its long history.

The ash fields from Crater Lake to the Paulina-East Lakes are extremely dry, and only support a sparse, scrubby forest of Lodgepole Pine in most areas, although Ponderosa Pine is found in some areas where the ash soil is shallower. As a result, the forest floor is mostly barren and devoid of vegetation except for scattered shrubs of Bitterbrush (*Purshia tridentata*) and small tufts of grasses. However, there are many places in these ash fields where ground water does come to the surface, producing small creeks, seepage areas, and wet, boggy meadows. Stands of willows (*Salix* sp.) and Quaking Aspen (*Populus tremuloides* Michx.) occupy these wet areas together with a large diversity of herbaceous plants including wild strawberry (*Fragaria* sp.), columbine (*Aquilegia formosa* Fisch.), delphinium (*Delphinium menziesii* D.C.), penstemons (*Penstemon* sp.), Indian paintbrush (*Castilleja* sp.), and various composites.

Of the three species of xerophytic violets found along the eastern slope of the Oregon Cascades, only *V. nuttallii* var. *linguaefolia* and *V. purpurea* have been able to colonize the Mazama ash fields. *Viola douglasii* is found

on the juniper-sagebrush hillsides around Klamath Falls in southern Klamath County and again along the Metolius River in Jefferson County. The region between these two widely disjunct populations was buried under the Mt. Mazama ash fall, and the violet has never been able to successfully recolonize the Mazama ash fields. The thick rootstalk of V. douglasii appears to be adapted to a firm rocky or hard clay substrate, and it does not grow well in a loose, finely divided ash-pumice soil.

Although *V. nuttallii* grows well in the ash-pumice soil, it apparently requires considerable moisture in the spring, and is mostly restricted to the higher elevations where there is a heavy snowpack in the winter, for example around the Paulina-East Lakes. Only *V. purpurea* is common and widely distributed in the pine forests of the Mazama ash field, and it is largely restricted to the moist zones of pine forest near the edges of creeks and boggy seepage areas. Even in this fairly moist habitat, the individual plants of *V. purpurea* are very small, measuring only 2-5 cm. in diameter.

Two species of mesophytic violets have been able to colonize the wet areas in the Mazama ash fields from the high mountains to the west. Viola palustris is strongly restricted to the edges of creeks and lakes that remain permanently wet through the year, while V. adunca var. bellidifolia is extremely abundant in wet, boggy meadows that dry out for part of the summer. The violets often form a dense carpet of plants in many parts of these meadows, but the individual plants are very small as in V. purpurea, measuring only 1-5 cm. in diameter.

Five different species of Speyeria have been able to colonize the Mazama ash fields, including S. mormonia, S. egleis, S. zerene, S. coronis, and S. callippe. Moeck (1957) and Tilden (1963) previously studied the Speyeria populations in this region. Speyeria mormonia occupies the wet, boggy meadows, utilizing V. palustris and V. adunca as larval foodplants. The butterfly has almost certainly invaded and colonized the Mazama ash fields together with these violets from the adjacent high Cascades to the west. However, S. callippe and S. coronis occupy dry, open habitats, and have probably invaded the Mazama ash fields from the adjacent sagebrushjuniper lowlands to the east, which constitute the usual habitat of these xeric species. Because the Mazama ash fields are mostly covered with Lodgepole Pine forests, S. callippe and S. coronis are usually rather rare in this region due to the scarcity of open habitats, but particularly large populations breed in the open, moist areas around the Paulina-East Lakes. Speyeria callippe is the dominant species around these lakes, while S. coronis is less common and S. mormonia is restricted to the wet, boggy habitats. Thus, mesic S. mormonia and xeric S. callippe appear to have invaded and colonized the Mazama ash fields from opposite directions.

Speyeria zerene and S. egleis are the dominant species in the Lodgepole Pine forests of this region, but they are mostly restricted to the moist zones of pine forest near the creeks and boggy seepage areas like their V.

purpurea foodplant. While S. zerene is the usual Speyeria to occupy dry, open pine forests throughout western North America, it is often rather scarce on the Mazama ash fields, and is often replaced in this habitat by large populations of S. egleis. This latter species has invaded and colonized the Mazama ash fields from the Mt. McLoughlin and Lake-of-the-Woods ash fields in southern Klamath County. Evidence of this invasion is suggested by the physical characteristics of butterflies from clinal populations between Lake-of-the-Woods and Crater Lake. In addition to occupying pine forests at low elevations east of Crater Lake, S. egleis also occupies barren pumice fields around the rim of Crater Lake itself.

The unique feature of these Mazama S. egleis is their very small size, which appears to represent an adaptation to the small, dwarfed size of their larval foodplant. For comparison, a sample of  $64\,S$ . egleis males from near Lake-of-the-Woods had a forewing length range of  $23\text{-}28\,\text{mm}$ . ( $\overline{X}=26\,\text{mm}$ .), while a sample of 71 males collected on the Mazama ash fields east of Crater Lake had a range of  $21\text{-}25\,\text{mm}$ . ( $\overline{X}=23\,\text{mm}$ .). As such, the Mazama S. egleis rank among the smallest of all Speyeria butterflies in existence. These samples are illustrated in Figure 1., and the difference between the sample means is highly significant ( $\mathbf{Z}^2$ p<0.0001). Moreover,

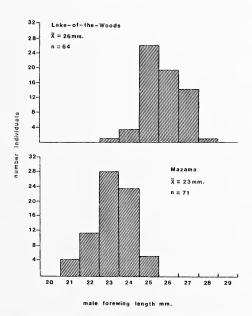


Fig. 1. Comparison of male forewing length in *Speyeria egleis* samples from the Mazama ash fields of northern Klamath Co., Oregon, and near Lake-of-the-Woods in southern Klamath Co.

laboratory rearing experiments conducted by D. V. McCorkle of Monmouth, Oregon, and O. D. Spencer of Lincoln, Nebraska, have shown that this dwarfed size is under strong genetic control, and is not merely an environmentally induced phenotype. McCorkle reared samples of *S. egleis* from several different areas under approximately identical conditions, and the largest specimens from the Mazama region of Klamath County reached 25 mm. while the largest from the Siskiyou Mountains of Josephine County reached 27 mm. Thus, the size of reared specimens from different areas closely corresponds to the size range of wild specimens, suggesting a strong genetic component to the determination of forewing length.

This Mazama form of *S. egleis* also differs from the Mt. Shasta-Mt. McLoughlin populations in coloration, exhibiting relatively little dark basal suffusion on the dorsal wing surfaces and often a reddish brown ventral hindwing. In contrast, the Mt. Shasta-Mt. McLoughlin *S. egleis* usually exhibit more extensive dark basal suffusion on the dorsal wing surfaces and a black-brown or umber brown ventral hindwing.

The Mazama form of S. egleis has a wide distribution in the central Oregon Cascades that corresponds very closely with the distribution of the ash-pumice fields in this region, extending from Crater Lake eastward to Yamsey Mountain and northward to the Paulina-East Lakes and the Three Sisters volcanoes in Deschutes County. Since this habitat did not even exist until after the destruction of Mt. Mazama about 6600 years ago, it would appear that this distinctive Mt. Mazama form of S. egleis has only evolved from the Mt. Shasta form during the past 6000 years or so. Considering the fact that the Mazama ash fields represent a particularly harsh, xerophytic environment, it is interesting to observe that this organism has been able to colonize and evolve in this new environment in such a short time period.

While S. egleis has successfully colonized the Mazama ash fields, S. cybele leto has been completely excluded from this region, and displays the same relict, disjunct distribution as Viola douglasii. Colonies of S. cybele are found around Klamath Lake in southern Klamath County and again along the Metolius River in Jefferson County, but the species has not been able to recolonize the intervening Mazama ash fields. Speyeria cybele leto is a large butterfly and apparently requires a large biomass of the larval foodplant, but the violets that grow in volcanic ash habitats are usually too small to support such a large butterfly (based partly upon observations of larvae reared by D. V. McCorkle).

#### Conclusions

The colonization of volcanic ash-pumice fields in the southern Cascade Range by violets and *Speyeria* butterflies is summarized in Table 1. For comparison, the normal habitats of the plants and animals in non-volcanic

areas are summarized in Table 2. These organisms demonstrate how plants and associated insects may colonize and adapt to new environments recently created by the eruptions of Cascade volcanoes. It is interesting that some violet species such as V. purpurea and V. nuttallii have been vigorous colonizers of the ash-pumice fields, while other violets such as V. douglasii have been conspicuously unsuccessful. Speyeria egleis has followed V. purpurea into the ash fields of Mt. Shasta, Mt. McLoughlin, and Mt. Mazama from the exposed, rocky habitats of the Sierra Nevada, Siskiyou, and Warner Mountains. In contrast, S. atlantis dodgei has followed V. nuttallii into the Mt. McLoughlin ash fields from the dry, open meadows and prairies of the high Cascades. Likewise, S. mormonia has followed V. palustris and V. adunca into the Mt. Mazama ash fields from the wet, boggy meadows of the high Cascades. However, both S. callippe and S. coronis have invaded the Mt. Mazama ash fields from the sagebrush-juniper lowlands east of the Cascade Range. Speyeria zerene is also a typical resident of the Mt. Shasta, Mt. McLoughlin, and Mt. Mazama regions where it occupies open dry pine forests; the same habitat the species occupies throughout much of western North America. However, S. cybele leto has been effectively excluded from ash-pumice habitats due to its requirement for a large biomass of the larval foodplant.

Acknowledgments. I am particularly indebted to O. D. Spencer, Ernst J. Dornfeld, and David V. McCorkle for their kind contributions of much assistance and data to this paper. I also want to thank L. Paul Grey for many long and stimulating discussions regarding these various Speyeria populations, and to several reviewers for suggesting numerous improvements in the manuscript.

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The Life of the Meadow Brown.

W. H. Dowdeswell, 1981. ca. 14 x 21 cm; 8+165 pp., 19 pls., 27 tabs., 29 figs. Heinemann Educational Books, London. Price: £ 5.95, paperback.

In this fascinating little book the author deals with the ecology of Maniola jurtina, one of the "most successful" of all European butterfly species. Professor Dowdeswell used this widespread and usually abundant satyrid both as the object of his field investigations and as a convenient research tool to answer some fundamental biological questions, mostly related to ecological genetics. His research programme began shortly after the end of World War II and extended over a period of some 30 years. It was conducted in cooperation with the acknowledged group of Oxford scientists centered around Professor E. B. Ford. The book is concisely written, describing both results and the thought processes directing the research that led from the formulation of the enquiry to its usually successful conclusion. Choice of methodology is discussed in some detail, making the book a very useful reading for less experienced students and amateur lepidopterists. It also clearly shows what can be achieved with relatively simple means. The text of the book is divided into seven chapters and provided with a list of the bibliographical references and comprehensive index. The following aspects of the life of Maniola jurtina are among those studied by Dowdeswell (the order follows approximately that used in the book): description of the adults and early stages, life cycle, related species, variation and its significance, population size and its fluctuation, island populations and aspects of isolation, spotting and its significance, 'boundary phenomenon', spot-placing as an index of variation, variation-types and their relationship, geography of variation, sex ratio, evolution of island stabilization, selection, behaviour, selective agents, ecological bacteriology, enzymes and adaptation, electrophoresis, inheritance of spotting, spot-variation. Field work, supplemented by laboratory experiments, took place in Great Britain (including some adjacent islands) and on the Continent, mainly in Holland and Italy.

A few unfortunate errors entered the text. The genus Maniola was described by Schrank and not by Linnaeus, as stated on page 6. References are not arranged in alphabetic order and they are cited in the text by numbers instead of the usual and significantly more convenient author's name; some papers are not cited in full and/or correctly (e.g. Atti Accad. naz. Lincei Rc. instead of incorrect Accademia Nazionale Dei Lincei on p. 159 and elsewhere). The taxonomic account of Maniola jurtina is perhaps far too brief, and, to my surprise, the only comprehensive paper on the systematics of the species is not to be found listed in the references: G. Thomson in Tijdschr. Ent. 116(1973): 185-227, 1974. If the reason for the exclusion of Thomson's paper was its abundant use of inconvenient multinominal combinations, denoting not only the superfluous subspecies, but also many individual and local forms, it should have been explained. In any case, it would have been very useful to have provided a comprehensive bibliography instead of the list of only 52 references. Thus the book and especially its readers would have gained much more. The species of the genus Hyponephele Muschamp which inhabit Europe should have been included among the British relatives of Maniola jurtina, as they are closer to it than many of the related species listed.

The book is well written, inexpensive and, above all, it shows new ways of taking interest in butterflies. Every lepidopterist should read it.

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Manuscript Format: Two copies must be submitted (xeroxed or carbon papered), double-spaced, typed, on  $8\frac{1}{2}$  x 11 inch paper with wide margins. Number all pages consecutively and put author's name at top right corner of each page. If your typewriter does not have italic type, underline all words where italics are intended. Footnotes, although discouraged, must be typed on a separate sheet. Do not hyphenate words at the right margin. All measurements must be metric, with the exception of altitudes and distances which should include metric equivalents in parenthesis. Time must be cited on a 24-hour basis, standard time. Abbreviations must follow common usage. Dates should be cited as example: 4. IV. 1979 (day-arabic numberal; month-Roman numeral; year-arabic numeral). Numerals must be used before measurements (5mm) or otherwise up to number ten e.g. (nine butterflies, 12 moths).

Title Page: All papers must have the title, author's name, author's address, and any titular reference and institutional approval reference, all on a separate title page. A family citation must be given in parenthesis (Lepidoptera: Hesperiidae) for referencing.

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COVER ILLUSTRATION: Artist's rendition of courtship behavior in the dainty sulfur, *Nathalis iole*. Figure was drawn from a 35 mm photograph by Patricia Rutowski. See page 33, R. Rutowski.

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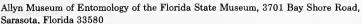
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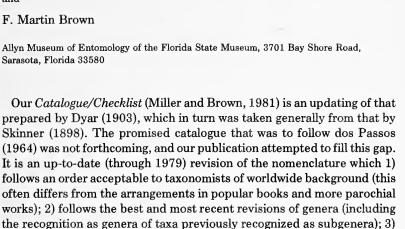
# Butterfly Taxonomy: A Reply

Lee D. Miller

and

F. Martin Brown





clature. It should be clearly stated here that no new names, at the generic or other level, have been employed by Miller and Brown (1981). In every case, the generic names are ones proposed validly by earlier authors. There are 669 notes which provide detailed information (often in telegraphic form because of space constraints) on authorities followed and, at least by implication, reasons for changes from pre-existing nomenclature.

considers higher taxa on their worldwide complement of species, not just those from the Nearctic; 4) takes into account biological and ecological advances in knowledge, such as different foodplant preferences that separate distinct, but previously overlooked genera; and 5) attempts to follow the International Code of Zoological Nomenclature. The Catalogue/Checklist does not take into consideration political constraints or the aspects of continued usage of incorrect, frequently employed names. Should the conservation of these names be desired, the place to apply for their reinstatement is the International Commission on Zoological Nomen-

Such a treatment as ours is not made without objections, and those complaints made by Ehrlich and Murphy (1982) require some objective replies. Their points are by no means new-similar reactions have followed every reclassification that has appeared. The catalogue format precludes detailed explanation of every change (though such changes are documented elsewhere in the literature); Ehrlich and Murphy's com-

plaints likewise are unsupported by specific explanations. The usual objections to nomenclatorial changes are: old, reliable, comprehensive genera are being split; the literature will be adversely affected by "wholesale name changes"; the new names do not reflect relationships, obscuring the affinities of species that "everyone knows belong together"; and that in general taxonomists are meddlesome creatures who keep themselves busy changing names for the sake of changing them for no biological purpose.

Attacks like those mentioned may be seen in the pages of Strecker (1876: 118-120) berating Scudder (1875), of Holland (1931: 325) and Forbes (1960) in their not accepting the work of Lindsey, Bell and Williams (1931), by Hovanitz (1962: 95-96) in his criticism of dos Passos and Grey (1947) and again by Hovanitz (1965: 18) regarding dos Passos (1964). In the latter critique, Hovanitz states, "Names proposed by splitters do not have to be used merely because they have been proposed." He did not, however, go so far as to suggest that these names be expunged from the literature.

We are being criticised essentially for being "out of touch" with modern systematic work, but are we? We had expected a certain amount of controversy to arise when the classical treatment of the Papilionidae by Munroe (1961) was expanded. This expansion was not done solely on the basis of the genitalia, as suggested by Ehrlich and Murphy (1982); rather the morphology of all life stages was considered along with biological parameters such as foodplant preferences. Munroe never claimed to have all of the answers for the Papilionini, and the passage from his work quoted by Ehrlich and Murphy indicates that he had questions about his ability to find differences within "Papilio", differences which have become apparent with more life history data. Our treatment, like that of Eliot (1978), generally follows the outline of Munroe's classification, but at a different level.

Each of the papilionid genera that we accepted is either a lauraceous, rutaceous or umbelliferous feeder (the main exception being Papilio, s. str., which contains some rutaceous feeders, apparently as a response to competition by congenors). Ferris and Emmel (1982) studied the rutaceous feeding P. polyxenes color W. G. Wright and showed that while it feeds in the wild on Rutaceae, its larvae actually do better on Umbelliferae, but it is out-competed for the umbellifers by the very successful P. zelicaon Lucas. This switching of foodplant groups within a phyletic line is interesting and may be of fundamental biological and systematic importance. While there are some biochemical similarities between a number of Umbelliferae and some Rutaceae, they are not biochemically identical! Berenbaum (1981) shows how narrowly Papilio, s. str., is tied to plants (chiefly Umbelliferae) with concentrations of furanocoumarins, and he further shows that rutaceous feeders within that genus also will utilize Umbelliferae that

contain these substances.

Perhaps the most characteristic furanocoumarin-bearing rutaceous plant is Citrus, the host of Heraclides and Priamides. This strongly indicates that these genera are sister groups of Papilio (perhaps Priamides, despite its structural dissimilarities, is a good subgenus of Heraclides), and that this cluster of genera is evolutionarily very different from the lauraceous feeders. Among Nearctic swallowtails, the lauraceous feeders are the ones Miller and Brown (1981) include in Pterourus.

These genera are not so restricted in numbers ("one species per genus") as a parochial examination of them would indicate. Papilio is found throughout the northern hemisphere and contains at least twice as many species as are represented in the Nearctic. Heraclides is a genus of at least 15 Nearctic and Neotropical species, Priamides contains at least ten species from the Neotropics and Pterourus has eight or more Nearctic and Mexican representatives. Further, while all are bird-lime mimics in early larval instars, only Heraclides and Priamides retain this character in later stadia. Pterourus larvae in later instars are green with thoracic "evespots", presumably as a sham defense, and mature Papilio larvae are conspicuously banded with green and black totally unlike other groups. The osmeterium of Papilio is shorter and stubbier than that of Heraclides and Pterourus. Thus, the statements by Ehrlich and Murphy (1982) about the division of "Papilio" by Huebner [1819] are merely their way of setting up "straw men" so that they could knock them down. In a much quieter way, we did the synonymization of these names to one another, and the fact that perhaps Huebner established genera for the wrong reasons or otherwise faultily cannot diminish that he did establish them.

Other examples could be cited, such as the objections to the division of "Lycaena" into constituent genera (Sibitani, 1974; Miller and Brown, 1979), but some of the comments made by Ehrlich and Murphy (1982) suggest that they did not really read these papers for content, only to find grounds for criticism.

Further criticism is rendered because we have "ignored perfectly good subgenera" and raised them to generic standing. This may be true, perhaps, but the steps were taken for reasons entirely different from the capriciousness attributed to us. Subgeneric names, if consistently applied, can indeed carry great taxonomic and evolutionary information. The difficulty is that most advocates of subgenera are not consistent. Thus, we have a situation analagous to that demonstrated by Eliot (1978: 121) where members of the genus Euploea Fabricius are tabularly divided into subgenera, which taxa are not mentioned again in the text. The "use" of subgenera in this way conveys little or no information about specific groupings, and Euploea is left as an apparently homogeneous assemblage of related species. Division of Euploea into separate genera (note that we are not advocating it), elevated from subgeneric standing and placed into a

well-defined hierarchical classification, does not obfuscate relationships, but rather, it strengthens them.

In North American butterflies, good candidates for demotion to subgeneric standing would include Occidryas, Hypodryas, Abaeis, Pyrisitia, Falcapica and Priamides, and we would then recommend reinstatement of at least the subgenera Semnopsyche and Erynnides. Nevertheless, while Ehrlich and Murphy admit the at least "weak subgeneric" status of Occidryas, they steadfastly refuse to refer to "Euphydryas (Occidryas) editha (Boisduval)", preferring a strict binominal designation. We could certainly accept consistent use of subgenera, but not the sporadic usage of taxonomic names at whatever level.

The arguments put forth on scientific vs. vernacular names are, we feel, specious and clearly irrelevant in the context of the rest of their paper. Much the same must be said about the thoughts expressed on species-level taxonomy. We shall comment neither on the correctness nor the political morality of the thoughts expressed by Ehrlich and Murphy (1982) on the reasons for naming subspecies, save to state that there are other thoughts on the matter.

It cannot be questioned that evolutionary problems are more complex than are reflected in the pages of popular texts: if they were not more complex, they would have been solved long ago. Perhaps Ehrlich and Murphy are correct when they accept the concept of the evolutionary unimportance of subspecies (Wilson and W. Brown, 1953), but acceptance of that idea also suggests that the detailed study of even smaller demes (for example, the *Occidryas editha* studies of Ehrlich and his coworkers) may not be entirely or even mostly evolutionary in nature. Gould (1982: 104) states unequivocally, "We cannot learn everything we need to know about evolutionary trends by studying what happens within demes, if only because species can act as units of selection." The key word in this quotation is "everything", and the key thought is that no one study contains *all* of the information needed to pass evolutionary judgments.

Another point that Ehrlich and Murphy (1982) seem to have forgotten is that evolution is a dynamic process, so it is natural that some taxa will be "better" (i. e., phyletically more divergent from other taxa) than others. Were evolution a static process, phenetic measures might show similarities and gaps, but since taxa are in varying stages of divergence, phenetic analysis does not always show relationships correctly. Within taxonomic lines, some taxa are diverging more rapidly, others less, than their closely related counterparts. Whether one accepts classical gradualism, the punctuated equilibrium theory of Eldredge and Gould (1972) and Gould and Eldredge (1977) or something that embodies parts of both theories, it is clear that taxon "A" might well evolve, by one means or another, faster or slower than taxon "B".

We object to formalization of the generic nomenclature in Howe (1975)

chiefly because that book is replete with errors (Ferris, 1976) and because the nomenclature is at odds with that recognized by specialists throughout the world. Similarly, we must also reject the attempt to formalize the higher classification of Ehrlich (1958) and Ehrlich and Ehrlich (1967): that particular proposal is self-serving. Our argument with the Ehrlich schema is not necessarily with the arrangement of taxa (we more or less agree), but rather, with the taxonomic levels in which the categories are placed. The statement (Ehrlich, 1958) that his classification was somehow more in line with those adopted in other insect orders was not convincingly defended: nor did that classification take into account what is known about fossil butterflies simply because so many of the relevant examples have been discovered in the last two decades. Many of these fossils indicate slower, a few faster, rates of evolution than would be indicated by the five to eleven million years' duration for invertebrate species given by Raup (1978) and Stanley (1979). Gould (1982:95) suggests, however, "...some species may survive longer than others because they inhabit a certain kind of environment, not because their morphologies are 'better' in any conventional sense." Again, we must reiterate that the last word has not been written on butterly higher classification or phylogeny.

This reply is essentially a plea for additional research, unfettered by concerns about "sacred cows". We were somewhat loath to write this article, but the mere suggestion of the suppression of Miller and Brown (1981) by Ehrlich and Murphy (1982) left us with no alternative. We reject their call for censorship, wondering to what other papers it ultimately might be applied: science is the censor, not individual scientists or editors.

In the Editor's Note preceding Miller and Brown (1981), C. V. Covell, Jr., states, "No arrangement of taxa has yet proved to be the 'right' one, and we expect the years and the gristmill of scientific discourse to bring us closer to a true phylogenetic classification of the Lepidoptera." Our work was written in that spirit, and we welcome the renewed interest in taxonomic investigation that we hope it spurs. It is only through such research that progress can be made.

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# Nomenclature, Taxonomy and Evolution

Paul R. Ehrlich

and

Dennis D. Murphy

Department of Biological Sciences, Stanford University, Stanford, CA 94305

This response to Miller and Brown (1983) will have to be relatively brief, since we do not have room here to teach elementary courses in systematics or evolution. Miller and Brown seem to be under the impression that we were critical of their taxonomy, as the title of their paper—"Butterfly Taxonomy, A Reply"—indicates. On the contrary, as the title and content of our original paper (Ehrlich and Murphy, 1982) show, we were critical of the nomenclature they used, not the taxonomy. They thus miss the entire point of our critique, because nomenclature is not taxonomy, and certainly not biology! In his basic text Principles of Systematic Zoology, Ernst Mayr (1969, pp. 407 and 413) defines nomenclature as "a system of names" and taxonomy as "the theory and practice of classifying organisms." He further points out (p. 297):

"It is the role of nomenclature to provide labels for taxa at all levels, in order to facilitate communication among biologists. The scientific names for species of organisms and for the higher taxa in which they are placed form a system of communication, a language; they must fulfill the same basic requirements as any other language."

Mayr's three outstanding attributes for scientific nomenclature are uniqueness, universality, and stability. Of the latter he says (p. 298):

"As recognition symbols the names of objects would lose much of their usefulness if they were changed frequently and arbitrarily. It would surely create confusion if we were to call an object a spoon today but an apple next week. Yet this basic principle of communication has been constantly violated by zoologists. Altogether too much name changing has occurred in zoological taxonomy during the past 200 years."

Similar sentiments are found in the other standard source, George Gaylord Simpson's *Principles of Animal Taxonomy* (1961). For example, he makes the following point with emphasis (p. 112):

"A published classification in current use should be changed when it is definitely inconsistent with known facts and accepted principles, but only so far as necessary to bring it into consistency."

A nomenclature can remain relatively conservative to facilitate communication while the underlying classificatory system can be more fluid to represent, at best partially, better understanding of relationships. But, as Simpson admonishes, there should be strong reasons even for changing the taxonomy, let alone the nomenclature.

In this context, the notion that we were recommending "censorship" in proposing to stick to names in Howe unless there were reasons (clear polyphyly, highly distorted balance) for not so doing is seen as preposterous. Standardization is routine in scientific discourse. If Miller and Brown submitted to *Science* or any other refereed scientific journal an article that contained measurements in chains, rods, bushels, or pecks it would be rejected until those measurements were replaced with their metric equivalents. Would that be censorship??

We cannot help but note in passing, in terms of "censorship" that the Journal of the Lepidopterists' Society refused to publish our original manuscript on the novel grounds that the Society had published Miller-Brown. This refusal was surely a "first" for purportedly scientific journals, the rest of which routinely publish critiques of their previous articles. Furthermore the society is now going to require that all contributors to its season summary follow Miller-Brown nomenclature (News of the Lepidopterists' Society, Sept/Oct 1982, p. 62), even though a major segment of the society (see acknowledgments to Ehrlich and Murphy, 1982)—in fact, if our sample is representative, the vast majority of its members—think that nomenclature a disaster.

Some specific replies:

- 1. Catalogues are not the place to put unexplained new taxonomic arrangements.
- 2. There are no "overlooked" genera; most of the ones resurrected in Miller-Brown were correctly long-ignored.
- 3. The "no new names" issue begs the question. Names dredged out of synonymy where they have properly resided for a century and a half are operationally "new."
- 4. Generally the notes in Miller-Brown are utterly inadequate to justify the nomenclatural changes, since they do not deal with crucial issues of polyphyly or balance. For many of the more egregious choices, such as the resurrection of *Pterourus*, no explanation is given there at all. In others they follow nomenclaturally incompetent "revisions," for instance, accepting "Occidryas" even though Higgins (1978) gives no valid reason for proposing it as a genus.
- 5. Not using a name does not mean it will be "expunged from the literature."
- 6. Miller and Brown nicely summarize all of the reasons that their nomenclature should be rejected in the section "The usual objections... biological purpose." Hovanitz' (1964) objection to the splitting of Speyeria

from *Argynnis* is perfectly valid—we have not suggested going back simply because *Speyeria* has now become widely accepted. Hovanitz' other comments show how prescient he was about the downhill slide of butterfly nomenclature.

7. Nowhere did we "suggest" that the division of Papilio was based on genitalia—our only reference to genitalia was to the dependence upon them at the specific level. Miller and Brown now justify the nomenclatural inflation primarily on the basis of food plant differences. Their main criterion is that "Papilio" feeds on Umbelliferae, "Heraclides" on Rutaceae, and "Pterourus" on lauraceous plants. But "Heraclides" is also on Piperaceae, "Papilio" is commonly also on Rutaceae and Compositae in addition to Umbelliferae, and "Pterourus" feed on many families (Papilio glaucus and P. rutulus are recorded from at least 15 families) including Rutaceae! The correct interpretation of Berenbaum (a she not a "he") is not that natural groupings of swallowtails feed on natural groupings of plants, but that certain swallowtails are highly catholic in their choice of oviposition plants, as long as the plants share a similar chemical stimulant.

But even if different subgenera or species groups did feed exclusively on different groups of plants, that, in itself, is not an excuse for raising them to generic status. The subtleties of the factors governing larval host plant use by butterflies are just beginning to be elucidated (e.g., Chew, 1977; Holdren and Ehrlich, 1982; Lincoln, et al., 1982; Murphy, 1983; Rausher, 1982; Singer, 1972; Wiklund, 1982). Taxonomic affinity of the plants is just one such factor, and in many cases a minor one to boot (Janzen, 1979). Celastrina argiolus is known to feed on at least 18 plant families and Strymon melinus on 28. Will the next nomenclatural epic fraction them into 18 and 28 genera respectively?

The basic point, of course, recognized by all well-trained taxonomists, is that levels of genera, subgenera, etc. are biologically purely arbitrary, and that the use of genera should therefore be conservative to aid in communication (Mayr, 1969, p. 239). In addition, reclassification of Papilio does not remotely meet Simpson's criterion—there are no "known facts and accepted principles" that are violated by retaining Papilio in the sense that it has been used for the past few decades. The bottom line is that even the discovery of natural groups within Papilio would not in itself, be a reason to split the genus and change hundreds of names. Polyphyly or severe imbalance would be such a reason, but unless one or the other can be clearly demonstrated, taxonomic structure within Papilio should be recognized by subgenera or species groups.

Additionally, we must note Miller and Brown's story about *Papilio polyxenes coloro*. Although it has no direct relevance to the issue under discussion, it highlights how casual speculation in the literature gets translated into fact. Ferris and Emmel (1982) present not one shred of

evidence bearing on whether *P. zelicaon* did, does, or can "outcompete" *P. p. coloro*—nor do they claim to. Such evidence would be of enormous interest to the ecological and evolutionary communities as a whole, as competitive exclusion has never been demonstrated in herbivorous insects.

- 8. Large, uniform genera should not be broken up just because they are large—quite the opposite. And to fractionate small, uniform genera such as *Euphydryas* (12 species) is absurd. What possibly could be gained by dividing it in four?
- 9. Consistent application of subgenera does not mean burdening communication with them if there is no need. The genius of the Linnean system of binomial nomenclature is its parsimony—it avoids the older system of using an entire phrase to denote an organism. The idea is to maximize communication while restricting oneself to a two-part name.
- 10. Nomenclature that is "recognized by specialists" is, especially in groups like the butterflies where many specialists have extremely narrow training (or none at all), almost invariably oversplit. Rare is the specialist who considers broad balance in his or her application of names. One result of this is a continual shifting of names, often accompanied—as in the Miller-Brown catalogue—by no significant advance in understanding of the organisms. Continual name-changing, we repeat, is the major reason why most biologists consider taxonomy a non-science. Taxonomy is too important to evolutionary and ecological biology to destroy its reputation to please those who confuse manipulating names with science.
- 11. We are glad to be told that evolution is a dynamic process. Miller and Brown might like to be informed that everything they say in the three paragraphs that start "It cannot be questioned that evolutionary problems..." and end "...classification or phylogeny." is gibberish, irrelevant to the debate at hand, or both. Those familiar with taxonomic and evolutionary theory will see that by simply reading them. Others can get the flavor by considering the phrase "Were evolution a static process..." (our emphasis). Presumably what Miller and Brown mean is that evolution in different lines can proceed at different rates (a textbook discussion can be found in Ehrlich et al., 1974). If there have been significant rate differences in the lines leading to different groups of butterfly species (it is not known if there have been), this would not make one iota of difference in whether conservative nomenclature could be applied to the products of butterfly evolution.

It might be noted that the question of whether nomenclature should be conservative is not only independent of evolutionary rates but also of notions of what kinds of relationship should be the basis of taxonomic schemes. For example, Ehrlich and Ernst Mayr were on opposite sides of the phenetics vs. phyletics arguments of a quarter of a century ago, but they are in close agreement on keeping obligatory categories conservative.

- 12. From the comment on "political morality" we can only assume that Miller and Brown are more interested in conserving generic names than in conserving butterflies. We would claim that the only moral course (indeed the only sane one) is to use every available scientific and political tool at our disposal in attempts to save Earth's dwindling biological resources. This issue is explored in depth elsewhere (Soule and Wilcox, 1980; Ehrlich and Ehrlich, 1981).
- 13. Splitting and unsplitting genera, or the publication of catalogue/checklists, will not bring us any closer to a "true phylogenetic classification of the Lepidoptera." Even if "phylogenetic" is rigorously defined, a phylogenetic classification is not even necessarily the most desirable goal.

One might view this whole argument as scientifically trivial, but it is not. Sound nomenclature is important to evolutionists, ecologists, and other biologists as well as systematists. Butterflies are prominent organisms, fast becoming one of the most important groups of experimental animals. Confusing and senseless changes now will only impede scientific investigation, confuse serious amateur lepidopterists, and unnecessarily further lower the esteem of taxonomists in their colleague's eyes.

In summary, we state again that the Miller-Brown catalogue/checklist is, as a bibliographic tool, one of the most useful publications on North American butterflies ever to appear. In its introduction (p. v) we find that of the two authors "the elder [Brown]. . .favors the use of subgenera, the younger does not." It is too bad that Brown's mature taxonomic judgment did not prevail. It would be a shame if the resultant misuse of generic names were to be widely followed and thus cause the work to have an overall negative impact on science as a whole and the study of butterflies in particular.

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#### **Editor's Note**

The above papers raise an issue which cannot be ignored, with regard to publication of and use of butterfly nomenclature. The crux of the issue is stability, with its corollary of conservatism. Under the present circumstances the nomenclature of the holarctic butterflies is anything but stable, not only by virtue of the new catalogue/checklist and substantial support for a different view of both taxonomic concepts and nomenclature, but by the proliferation of generic names in the Palearctic region. Pragmatically, the situation leaves this journal with the problem of what should be the accepted nomenclature for submitted papers. It is our position to accept the judgment of our reviewers in cases of controversy. Selection of reviewers will be made, insofar as possible, to provide balanced judgments. Thus, where options are available, the final decision will be between author and reviewers. Our bias, as was the strong bias of the founding editor, William Hovanitz, is for the conservative position. We wish to make very clear that despite this bias, we will not impose any nomenclature as an editorial fiat. After all, the nomenclature is largely the result of taxonomic opinion, which, in absence of convincing supportive data for most groups, is just that.

We do emphasize, though, that a consensus on nomenclature, at least of the higher classification, be arrived at as a matter of the highest priority for Lepidopterists. The reasons for such consensus are clearly stated by Ehrlich and Murphy. This Journal will continue to publish relevant considered judgments on the subject with the objective of reaching that goal.

It should be reiterated that we do not wish in any way to impugn publications of the Lepidopterists Society or create the impression of any relationship other than one of respect and support for that organization.

Editorial Board: R. H. T. Mattoni, John Emmel, Arthur Shapiro, Bjorn Petersen, Otakar Kudrna, Miguel R. Gomez Bustillo, Emilio Balletto, Atuhiro Sibatani, Ichiro Nakamura.

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Glenn Gorelick

Philip Ackery
Richard Arnold
Emilio Balletto
Michael Bentzien
Lincoln Brower
F. Martin Brown
Frances Chew
Julian Donahue
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# Notes on the Life History and Baja California Distribution of Chlorostrymon simaethis sarita (Skinner) (Lepdioptera: Lycaenidae)

John W. Brown<sup>1</sup>

791 My Way, San Diego, California 92154

**Abstract.** The early stages of *Chlorostrymon simaethis sarita* (Skinner) are herein described. Larval behavior in association with the host plant *Cardiospermum corindum* Linnaeus (Sapindaceae) is briefly discussed. Additionally, data regarding the insect's temporal and spatial distribution in Baja California, Mexico, are presented.

### Introduction

Chlorostrymon simaethis (Drury) is an exquisite little neotropical hair-streak that occurs from Florida and Texas south through the Antillies, Mexico, Central and South America (Nicolay, 1980). Although commonly associated with balloon vine (Cardiospermum Linnaeus) (Sapindaceae) throughout its entire range, the early stages of C. simaethis are seldom encountered. Zikan (1956) briefly described the last instar larva and pupa from specimens collected and reared near Itatiaia, Brasil.

In Baja California, Mexico, the subspecies *C. simaethis sarita* (Skinner) is occasionally moderately abundant. Additionally, balloon vine has a rather widespread distribution throughout the peninsula of Baja California and on the adjacent islands (Wiggins, 1980), with 3 species present, all in the genus *Cardiospermum*. The plant's fruiting bodies are round or angular, inflated, papery, three-chambered pods 2-4 cm long, 3-5 cm wide, and strongly veined (Coyle and Roberts, 1975). Each chamber usually bears a single pea-like seed, although in some cases only one or two of the three seeds develop to maturity.

Larvae of *C. simaethis sarita* were discovered inside the pods of a large *Cardiospermum corindum* Linnaeus at a locality approximately 10 km north of Rosarito, Baja California Norte, 8 April 1982, by David Faulkner and the author. Almost all stages of larval development were present.

# **Early Stages**

First instar. Length 2-4 mm. Body eruciform, light translucent green with a whitish overcast. No conspicuous markings. Second instar. Length

<sup>&</sup>lt;sup>1</sup>Departmental Assistant, Entomology Department, San Diego Natural History Museum, P. O. Box 1390, San Diego, CA 92112

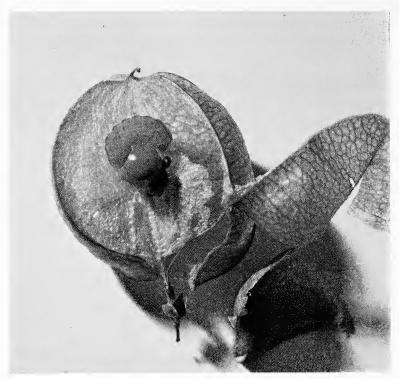


Fig. 1. Last instar larva of Chlorostrymon simaethis sarita inside pod of Cardiospermum corindum.

5-6 mm. Body light green to gray-green with a faint mid-dorsal darker stripe. No additional markings. Third instar. Length 7-8 mm. Body slugshaped, color quite variable from light olive green to light brown, a darker green longitudinal stripe running the entire mid-dorsal length. Body occasionally with minute reddish speckling. At mid-dorsal crest of each segment 2-8 is a wedge-shaped reddish brown mark and a slight ovaloid indentation. Marks usually well defined but may be quite faint. Mark on third segment enlarged, extending laterally almost over entire dorsal surface of that segment. Mark on second segment extremely light. A faint blackish gray longitudinal stripe on each side of the body. Head concolorous with body. Final instar. Length 9.0-11.5 mm; width 4.5 mm. Color and markings variable. Body color from light green to light brown, becoming powdery brick red as larva approaches pupation. Most of body covered with fine, short black hairs. Each segment with a black semilongitudinal dash midway between the apex and the prolegs; the dashes together forming an irregular, wavy, longitudinal stripe on each side of the larva. A mid-dorsal greenish black stripe runs the length of the larva, and a

small, variable faint-to-dark reddish brown oval-shaped marking occurs on each side of the stripe at the posterior crest of each segment 2—8. The markings together superficially appear as a reddish brown longitudinal stripe down the mid-dorsal apex. Mark on the third segment enlarged, extending laterally. Spiracles unmarked. Head, when extruded, reveals two conspicuous, small black ocelli. Mandibles brownish black. **Pupa**. Length 7.5-8.5 mm; width 4.5 mm. Short, stout, and rounded. Color variable, light brown to dark grayish brown, mottled with black and brown splotches. Ventral surface much lighter. Dark black markings inconsistently border the wing cases. A black comma-shaped spot on each side of the body near the region of the head. A faint black mid-dorsal longitudinal stripe; and a thin, black lateral stripe where abdominal segments six and seven join. Entire body sparsely covered with fine light brown hairs, wing cases bare.

Adults emerged as follows: 299, 4 May 1982; 19, 5 May 1982; 299, 8 May 1982; and 19, 10 May 1982. Five specimens are deposited in the collection of the San Diego Natural History Museum, and one specimen was given to Glenn Gorelick, Sierra Madre, California.

The molts were determined by observation of distinct changes in size of the larvae accompanied by subtle changes in coloration and markings. No head capsules were observed or recovered, and no immature stages were preserved.

## **Behavioral Notes**

Eggs are apparently deposited singly on the developing flower heads. Larval development takes place entirely within the fruiting pods. First instar larvae bore into a developing green seed, leaving behind a small entrance hole. Feeding initially takes place inside the seed and the frass is generally deposited on the exterior of the seed. The larva eventually consumes all of the seeds within a single pod, moving between the chambers of the pod by boring through the membranous structures dividing them. Occasionally even the membrane is consumed by the larva. There is never more than one larva within a single pod. Cannibalism might account for this fact since many lycaenid larvae, under crowded conditions, are known to devour their siblings (Downey, 1962). However, no cannibalism was observed. A single egg per bud is suggested by the occurrence of a single larva within a pod. Externally there is no difference in the appearance of inhabited and uninhabited pods.

After all the seeds within the pod have been eaten, the mature larva bores out of the pod and crawls away to pupate. Pupation occurs in debris and loose soil beneath the host without a girdle-string attachment. Under laboratory conditions, pupation of progeny of the spring brood lasted from 14 to 17 days.

It is not known whether a larva can undergo complete development

within a single pod, and the data available are inconclusive. Pods which had an exterior hole contained no larvae and were full of frass, indicating that the hole is an "exit" hole only, implying the use of a single pod. This was, however, contradicted by the fact that under laboratory conditions, mature-appearing larva continued to feed if offered a second opened pod. Also, Zikan (1956) reported the use of multiple pods of *Cariospermum halicacabum* Linnaeus. The contents of two pods seemed to be the absolute maximum required for complete larval development.

Observations by Fred T. Thorne (personal communications) indicate that newly hatched first instar larvae refused to feed on foliage of *Cardiospermum halicacabum* even when offered tender young growth. As *C. halicacabum* has been documented by Zikan to be a suitable host, this further suggests that the larval diet is indeed limited to the developing seeds. Although many lycaenid larva feed on vegetative parts of their respective hosts, several feed exclusively on plant reproductive structures such as flowers and seeds (Downey, 1962). The latter is the case with *C. simaethis sarita*.

## **Distributional Notes**

Chlorostrymon simaethis sarita occurs the entire length of the peninsula of Baja California, Mexico (Fig. 4). Captures have been recorded from the cape region of Baja California Sur to the Sierra San Pedro Martir in Baja California Norte. Strays are known from as far north as the Colorado Desert in San Diego County and Palm Springs in Riverside County, California, much to the north of the known range of the host. The single confirmed host in Baja California is the widely ranging introduced Cardio-

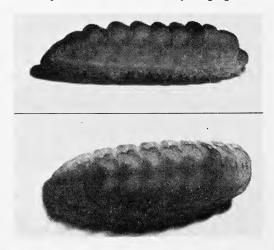


Fig. 2. Last instar larva of *C. simaethis sarita*, lateral view. Fig. 3. Last instar larva of *C. simaethis sarita*, dorsal view.

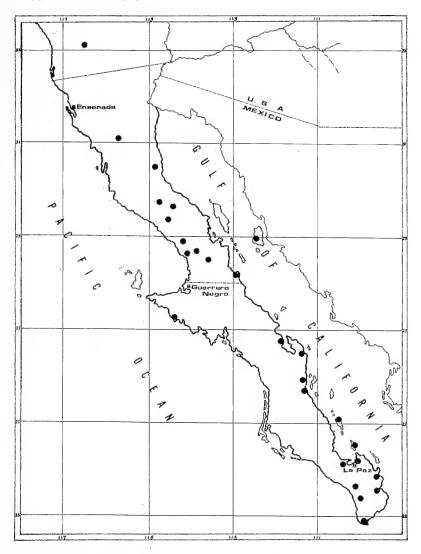


Fig. 4. Spatial distribution of C. simaethis sarita in Baja California, Mexico.

spermum corindum. It is not known whether *C. simaethis sarita* utilizes the other two species of *Cardiospermum*, both of which are endemic to Baja California.

In the northern arid region of the peninsula *C. simaethis sarita* appears to be capable of three broods, with the adult emergence probably dictated by rainfall. Capture records indicate flights in late March to mid-April mid-June to mid-July, and again in September through November. In the cape

region of Baja California Sur specimens have been recorded in every month from October to March representing at least two broads.

# Specimens Examined

Depositories abbreviated in the text are as follows: CAS, California Academy of Sciences, San Francisco, California; CI, College of Idaho, Caldwell, Idaho; HF, Allan Hancock Foundation, University of Southern California, Los Angeles; SDNHM, San Diego Natural History Museum, San Diego, California, and RB, Richard Breedlove, San Diego, California.

MEXICO: BAJA CALIFORNIA NORTE: Punta Prieta, 2 F, 28 March 1935 (CAS), 1 F, 23 Dec. 1976 (D. Lindsley, SDNHM); Sulfur mine S San Felipe, 2 F, 1 M, 12 Nov. 1967 (D. Patterson, CAS); 7 mi W Las Arrastras, 3 F, 18 M, 4 Nov. 1967 (D. Patterson, CAS); 14.9 mi N Laguna Chapala, 1 F, 1 M, 3 April 1973 (D. Patterson, CAS); 7 mi SW Mission San Borja, 1 M, 31 March 1973 (Donohoe & Patterson, CAS), 1 F, 3 M, 30 March 1973 (J. Powell, CAS); 7 mi E Rancho Rosarito, 16 F, 11 M, 30 March 1973 (Donohoe & Patterson, CAS); 9 km NW Rancho Santa Inez, 1 M, 12 July 1979 (A. Chu, CI); Rancho Santa Inez, 1 F, 14 June 1979 (J. Miles, CI); Las Encinas, Sierra San Pedro Martir, 1 M, 17 June 1980 (J. Brown, SDNHM), 1 M, 13 July 1980 (J. Brown, SDNHM); vic. ent. Parque Nacional Sierra San Pedro Matir, 1 F, 22 June 1979 (J. Brown, SDNHM); Bahia San Francisquito, 1 F, 3 April 1947 (C. Harbison, SDNHM); Isla Tiburon, Golfo de California, 2F, 3M, 19 March 1962 (C. Harbison, SDNHM); 2.1 mi S Rosarito, 1M, 23 March 1981 (Faulkner & Andrews, SDNHM); 10 km N Rosarito, 2 F, ex-larvae, em: 4 May 1982, 1 F, ex-larva, em: 5 May 1982, 2 F, ex-larvae, em: 8 May 1982, 1 F, ex-larva, em: 10 May 1982 (J. Brown, SDNHM).

BAJA CALIFORNIA SUR: Espiritu Santo Island, 2 F, 7 March 1928 (Craig, CAS), 2 F, 7 M, 22 Feb. 1936 (J. Garth, HF), 1 F, 11 Feb. 1940 (J. Garth, HF), 1 F, 9 M. 19 Feb. 1932 (J. Garth, HF); 10 mi N Todos Santos, 4 F, 9 M, 26 Dec. 1958 (Leech, CAS); Coyote Cove, Bahia Concepcion, 1 F, 1 Oct. 1941 (CAS); 13.1 mi NW La Paz, 2 M, 3 Jan. 1959 (Leech, CAS); Cabo San Lucas, 1 F, 17 Jan. 1959 (Leech, CAS), 2 F, 31 Dec. 1978 (Rude, CAS); 5.6 mi SE San Perdito, 1 F, 6 Oct. 1981 (D. Faulkner, SDNHM); 12.2 mi SE San perdito, nr Rancho Saucito, 2 F, 8 Oct. 1981 (Faulkner & Andrews, SDNHM); 14 mi N Todos Santos, 1 M, 4 Oct. 1981 (Brown & Faulkner, SDNHM); 29.9 mi S Loreto, 1 F, 11 Oct. 1981 (Faulkner & Andrews, SDNHM); 5 mi W Loreto, 8 F, 27 Dec. 1976 (D. Lindsley, SDNHM); Bahia Concepcion, 1 F, 29 Dec. 1976 (D. Lindsley, SDNHM); 2 mi W Loreto, 1 F, 4 M, 12 Dec. 1976, 2 mi SW Loreto, 1 F, 3 M, 4 Dec. 1977, 2-3 km SW Loreto, 1 F, 29 Nov. 1977, 1 F, 30 Nov. 1977 (all G. Forbes, SDNHM); Hotel Mulege, 1 F, 23 March 1974 (G. Forbes, SDNHM); La Paz, 1 F, 9 Nov. 1952 (SDNHM), 1 F, 1 M, 29 Nov. 1979 (Brown & Faulkner, SDNHM); Cabo San Lucas, 1 F, 11 Nov. 1952 (SDNHM), Hotel Finisterra, Cabo San Lucas, 3 F, 1 M, 30 Nov. 1979 (Brown & Faulkner, SDNHM), 4 F, 1 M, 28 Nov. 1980 (Brown & Brown, SDNHM); San Bartolo, 3 F, 1 M, 30 Nov. 1979 (Brown & Faulkner, SDNHM).

CALIFORNIA: RIVERSIDE CO.: Palm Springs, 1 F, 9927 (SDNHM).

SAN DIEGO CO.: Mason Valley, Anza Desert, 1 M, 8 Oct. 1967 (G. Forbes,

SDNHM); Anza Desert, Vallecitos, 1 M, 11 Nov. 1967 (R. Breedlove, RB); Dexter Peak, Descanso, 1 F, 21 May 1966 (R. Breedlove, RB).

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# Biology and Immature Stages of Australian Ethmiid Moths (Gelechioidea)

Jerry A. Powell

Department of Entomological Sciences, University of California, Berkeley, CA 94720

Abstract. Biological data for 5 species of Ethmia are reported, E. sphaerosticha, E. postica, E. thoraea, E. heptasema, and E. heliomela, based on observations in New South Wales and Queensland in 1980-81. Their eggs are characterized, along with larvae and pupae of the first and last species. The larva and pupa of E. hemadelpha from Western Australia and the pupa of E. nigroapicella from Hawaii are described. Known or suspected foodplants of all seven are Boraginaceae.

Ethmiids are small, often brightly colored moths sharing a general similarity in superficial appearance throughout all faunal regions of the world. There are remarkable differences, however, in less obvious morphological characteristics of the adults, in biological traits, and in the eggs, larvae, and pupae. The group is distinct taxonomically and has been regarded as a family (Sattler, 1967; Common, 1970; Powell, 1973; Kuznetsov & Stekol'nikov, 1979) or a subfamily of the large cosmopolitan family Oecophoridae (Hodges, 1978). In species diversity, ethmiids are best represented in areas of seasonal drought, such as the thorn scrub of the northern Neotropical Region. Each species is restricted in larval foodplant preference, and in general *Ethmia* are dependent upon Boraginaceae and the closely related, primarily Nearctic family Hydrophyllaceae (Sattler, 1967; Powell, 1973, 1980).

For its size, Australia has a depauperate ethmiid fauna, with only 14 species, but most of them are endemic, including some specialized forms (Powell, 1982). Among these, three species groups with differing male genitalia types exhibit striking similarity in these structures to Neotropical species groups that are known or believed to possess uniquely derived larval and pupal traits (*Ethmia*, Section II of Powell, 1973). Thus it was of considerable interest from a biogeographic viewpoint to discover whether the derived features of the immature stages in the New World are shared by Australian species.

During residence at the Division of Entomology, Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, in 1980-81, I was able to obtain some information on the biology of 5 species and received material collected by K. T. Richards of Perth, W.A.,

representing a sixth species. As a result, some data on oviposition behavior are summarized, and larval and pupal descriptions are given for 3 species. With existing descriptions of *Ethmia nigroapicella* (Saalmueller) (Moriuti, 1963; MacKay, 1972; Zimmerman, 1978), these data provide a representative picture for 4 of 5 Australian species groups outlined elsewhere (Powell, 1982).

# **Techniques**

Methods of handling living material were generally similar to those given previously (Powell, 1971). Moths were confined for oviposition either in plastic tubs ca. 25 x 25 x 13 cm with a cardboard floor and nylon stocking mesh ceiling, or in 10 x 1.5 cm glass or plastic petri dishes with nylon lining the lid. Newly hatched larvae were reared on branchlets of foodplant in plastic pill boxes or small refrigerator boxes; larger larvae were housed in plastic tubs or polyethylene bags lined with paper towels. Full grown larvae were offered folded paper towels and layers of soft corrugated cardboard, owing to the preference among many Holarctic *Ethmia* for burrowing into soft material for cocoon construction.

Rearing was conducted in uncontrolled laboratory temperatures, which varied widely. During hot periods larval lots were housed in better insulated, cooler rooms to deter disease. Nonetheless two larval groups became diseased; a common problem with communal rearing of *Ethmia* in North America (Powell, 1971).

Hostplant associations have been determined for three species, *E. hemadelpha*, *E. sphaerosticha*, and *E. heliomela*, by discovery of larvae in the field. For others, attempts were made to elicit oviposition response by providing Boraginaceae suspected to be hostplants, by correlation of the geographic distribution of moths and plants according to records in the Australian National Insect Collection (ANIC) and Herbarium Australiense, CSIRO, Canberra. Plant samples presented to moths or caterpillars were obtained from the National Botanic Garden, Canberra, or commercial nurseries.

Scanning electron micrographs were executed by Barry Filshie, using living eggs on leaf substrate. Ethmiid eggs seem to resist distortion due to the vacuum when processed in situ on leaves and need not be metal coated. In preservation, larvae were killed in hot water just below the boiling point. After sufficient distension occurred, they were transferred to Kahle's solution and ultimately to 95% EtOH. Measurements in larval and pupal descriptions were made by a micrometer disc at 6.3 to 20X magnification, of eggs at 20X to 40X. The number of individuals measured or observations upon which statements are based is indicated (n).

Consistent biological features of ethmiids have been summarized elsewhere (Powell, 1971, 1973) and are not repeated here. An exception to the oviposition pattern shown by Nearctic *Ethmia* occurs in two Australian

species, *E. heptasema* and *E. heliomela*, which usually deposit eggs in small clusters. In all previous records for the genus, and the 3 other Australian species I observed, oviposition is single. The eggs of *E. sphaerosticha* are flat, unlike any others known in the genus. None of the 4 species for which late instar larvae and pupae are known possess any of the uniquely derived features characteristic of *Ethmia* Section II of the New World.

# Ethmia sphaerosticha (Meyrick, 1886)

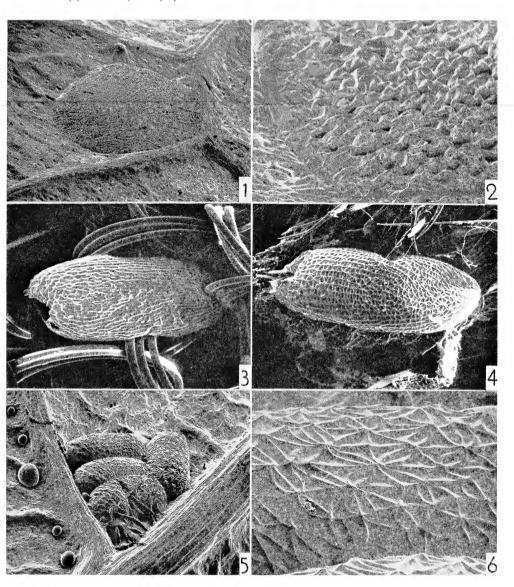
This species is unique among all known ethmiids for the enlarged antennae with expanding scale brushes in the male (Common, 1970: 814, Fig. 36.27k). The egg and pupal anchoring mechanism also differ from any previously described in the genus. *E. sphaerosticha* occurs in the rain forests of eastern coastal mountains, disjunctly, in northern Queensland and from southern Queensland to southern New South Wales (Powell, 1982).

Adult behavior.—Although they possess relatively small eyes (eye index 0.85; see Powell, 1973:8), the moths are nocturnal, and both sexes are attracted to lights. One male was taken flying at 1715 hrs, before sunset, but in laboratory confinement moths were diurnally inactive. Field-collected females (80M25, 81A105, A113, A121) survived 2-9+ days ( $\bar{x}$ =6, 7n). Two failed to oviposit, but the others deposited 25-30 eggs each. One female laid 10 eggs on day 7 of confinement, although only water was provided as nourishment. All eggs were deposited singly.

Females were housed in a plastic bag and plastic tub with a bouquet of *Ehretia acuminata* R. Br. in bloom (80M25) or in petri dishes with *Ehretia* leaves. About 50% of the eggs were placed on leaves, almost always on the undersides, irrespective of whether leaves were presented to the moths upsidedown or topside up, or as an upright bouquet. Only two eggs were laid on the upperside of a leaf in crevices. The remainder were placed on plastic or glass surfaces above the plant. None was laid on flowers, fruit or stems, or on the nylon mesh that is often selected by *Ethmia* (Powell, 1971).

Egg.—The eggs are flat, like those of tortricids, with both overall shape and surface sculpture (Figs. 1, 2) unlike those of any other described ethmiid. They ranged 1.17-1.40 X 0.67-0.80 mm in length and width and were weakly convex, less than 0.25 mm thick. Eggs took the form of the substrate, and their outline was highly variable. To the unaided eye the eggs appeared milky, and the color did not change during development, which was faster than in any other microlepidopteran I have observed. Only 5-6 days (80M25) or 4-5 days (81A113) were required until hatching.

Larva.—Newly hatched larvae were whitish, semi-translucent, including the head capsule (HC). They fed only on undersides of leaves, skeletonizing the surface and cutting tiny holes through the full thickness. After feeding



Figs. 1-6. Eggs of Australian Ethmia: 1, egg E. sphaerosticha on underside of Ehretia acuminata leaf (x30); 2, E. sphaerosticha, closeup of chorion sculpture (x235); 3, eggshell E. postica on nylon mesh (x42); 4, eggshell E. thoraea on leaf of Cynoglossum australe (x45); 5, egg clutch E. heptasema on underside of Ehretia acuminata leaf (x33); 6, E. heptasema closeup of chorion sculpture (x200). Magnifications approximated to published size.

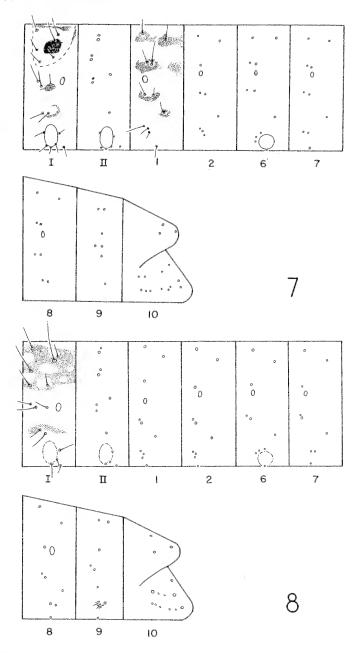
2-3 days, larvae appeared slightly greenish due to the gut contents and were extremely well camouflaged on the leaf surface. By the eighth day all larvae were in the 3rd instar, continuing to feed on the lower surfaces of leaves. Later instars also fed from beneath leaves, eating large holes but not feeding at the margins. They rested under flat webs on older leaves, migrating out to feed on newer foliage (in laboratory conditions). The flat webs were used for moulting by all instars, and seemed to be constructed only for this purpose. In the field (81A107) and lab (81A113) most moulting webs of antepenultimate and penultimate instars were constructed on uppersides of leaves no longer used for feeding or on container walls.

There were 6 discrete instars according to HC measurements (mm): I=0.31 (unfed) to 0.33 (shed HC); II=0.41 to 0.51 (shed HC's); III=0.98 to 1.02 (shed HC's); IV=1.19 to 1.23 (pres. larvae); V=1.42 (pres. larva) to 1.47 (shed HC); VI=1.76 (starved) and 1.96 (preserved) to 2.10 (living).

The first 3 instars were whitish with no integumental markings. A small black spot appeared on each frontal lobe in IV, along with tiny spots on D1 pinacula. In instar V larvae were cream colored, their spots increased in size, and sometimes small crescents were present below D2 and L pinacula. Extensive, variable black markings characterized the yellowish final instar (Fig. 7).

Growth was more rapid than that recorded for any North American ethmiid (Powell, 1971). The final instar was reached on day 15-17 following egg hatch, and full grown larvae appeared ready to pupate by day 19-24 (81A113), despite having fed on *Ehretia* which had been refrigerated 25-35 days. Those in lot 80M25 were not given additional leaves after day 7, owing to my absence on a field trip, yet nearly all reached the final instar and were starved or diseased by day 18. None was reared from egg through pupation, but those collected as last instar larvae produced adults 18-24 days following collection (80L47.1, 81A107). Thus the entire development from egg deposition to emergence can occur in 40-46 days.

Final instar larva.—Length 15.8 to 18.3 mm (starved individuals). Head: HC width 1.76 (starved) to 2.10 mm. Setation typical for the genus (e.g. MacKay, 1972); A¹, A², A³ and L¹ nearly on a straight line, with A² only slightly displaced posteriorly. Adfrontal sutures extending to cervical angle but abruptly approximate well below, adfrontal areas extremely narrow above P². Cream colored, broadly blotched with black across middle and narrowly along ventral border. Body: Primary setal arrangements of thorax and abdomen as in fig. 7. Pinacula of D, SD strongly raised. L1 and L2 on abdomen widely separated, especially on A1, and nearly on the same plane. Sclerotized depressions associated with spiracles or thoracic leg setae absent. No secondary setae except the usual gelechioid lower series of anal proleg. Integument yellowish or cream



Figs. 7, 8. Setal maps of *Ethmia* larvae, Roman numerals refer to thoracic segments, arabic to abdominal: 7, *E. sphaeorsticha*; 8, *E. hemadelpha*.

colored, variably mottled with black, often more extensively than indicated in fig. 7. Crotchets of abdominal prolegs irregularly biordinal, in a mesoseries, 26-28; anal leg crotchets similar, 24-26.

This is the only species of *Ethmia* known to lack secondary setae of the abdominal SV groups, including both the prolegs and A9. Fully fed larvae normally exceed the size range given.

Pupa (fig. 10).—Length 10.3-13.0 mm (4n). Head without projections, with a deep groove mesad of each antennal base, lined mesally and anterolaterally with dense patches of golden setae (fig. 11). Antennae and wings extended to posterior ½ of A5. A5 dorsally, A6-A7 dorsally and ventrally movable by deep intersegmental clefts. Dense, rust-orange, setaceus areas around spiracles of A2-A6, on sides and posterior edge of A5-A6, all exposed surfaces of A7-A9, and dorsum of A10 (fig. 12). Spiracles small, of uniform size on A2-A8, closed on A8. Anal legs represent by raised areas, not exceeding anterior edge of A9, densely covered with hooked setae.

The setaceous grooves of the pupal head (fig. 11), which have not been observed in any other ethmiid, are well developed in both sexes. Evidently they are not homologues of the modified male antennae. The anchoring mechanism restricted to A9, without free anal legs, is a unique feature among described *Ethmia*. It resembles that of certain Stenomatinae (Fracker, 1915), and it may represent the ancestral state for ethmiids.

In the laboratory cocoons were constructed in folds of paper toweling or in lumens of corrugated cardboard. They were moderately dense, opaque, about 18 mm in outside length and had a smooth interior cell about 14 x 4 mm, without the loose mesh known in some *Ethmia*. Normally *Ehretia acuminata* is a rain forest tree with its canopy high above the ground. At the Bunya Mountains, however, I found one tree in sparse natural woods with penetrating sunlight, so that the lowest limbs could be examined. The lower canopy contained many dead branches, most of which had hollow centers, probably the result of beetle and aculeate Hymenoptera burrowing. Splitting of a random sample of 20 branches 5-10 mm in diameter produced 2 old cocoons of *E. sphaerosticha* (determined by larval exuvium color and pattern of pupal shell setaceous areas). Both had appropriated abandoned borings in 1 cm sticks.

Nearctic ethmiids are known to wander from hostplant foliage to seek shelters or burrow into soft substances for pupation (Powell, 1971, 1973: 39). Considering the intermittently wet conditions of rain forest floor litter, pupation above the forest floor would seem to be selectively advantageous, and appropriation of abandoned holes in the canopy branches may be the preferred cocoon site for *E. sphaerosticha* and other tropical *Ethmia*.

The duration of pupation was relatively long, in contrast to the rapid larval life. One male emerged 16 days following initiation of cocoon construction (80L47.1); another emerged 19 days after the larval collection. Natural enemies.—Most of my rearings were from eggs laid in the lab, precluding parasitoids, but among 6 larvae collected from Ehretia, 2 were parasitized by Braconidae and Tachinidae (81A107). An undersized penultimate larva collected 6 January in an old shelter failed to feed, and 6 days later a braconid larva emerged and spun a cocoon, leaving a hole in the intersegmental area of abdominal segments 4-5. The Ethmia larva remained active another day without feeding, before it was preserved. It is interesting that larvae of E. arctostaphylella (Wlsm.) in California displayed this same behavior in response to parasitoid feeding and emergence by Apanteles (Braconidae), which emerged from the side of the 3rd abdominal segment (Powell, 1971: 46).

The tachinid developed its puparium within the pupal shell of *E. sphaerosticha* and emerged 6 days later than a male *Ethmia* that had been collected as a last instar larva at the same time. One of the two cocoons discovered in hollow *Ehretia* twigs at the Bunya Mountains also had an abandoned tachinid puparium inside the *Ethmia* pupal shell.

Voltinism.—Collection records of adults suggest two or more generations per season, with most records in November and January to March (Powell, 1982). Full grown larvae were present at Mt. Keira in late November, adults in late December, 1980. Final instar F<sub>1</sub> larvae from the latter (80M25) were preserved in mid-January and presumably would have produced adults by early February. Ethmia sphaerosticha has been collected at Mt. Keira as late as early April (1953 and 1964, V. J. Robinson); thus, it is possible that 4 flights occur: late October, mid-to late December, late January to mid-February and late March to early April. Overwintering presumably occurs as a pupa in diapause, as is known for multivoltine Nearctic species (Powell, 1971, 1974).

Collection data.—Mt. Keira, Wollongong, N.S.W., larvae 25/26 Nov. 1980 (JAP80L47.1), females (MV light) 20 Dec. 1980 (80M25); Bunya Mts., Q., females 5 Jan. 1981 (bl) (80A105), larvae 6/7 Jan. 1981 (81A107), female 7 Jan. 1981 (bl) (80A113); Whian Whian State Forest, NE of Lismore, N. S. W., female (bl) 12 Jan. 1981 (81A121).

# Ethmia postica (Zeller, 1877)

This is the most widespread ethmid on the Australian continent, occurring in interior areas from northwestern and south central W. A. to western Queensland, N. S. W., and Victoria (Powell, 1982).

Adult behavior.—The moths are nocturnal. Virtually all collections have been made at lights, and females confined in the lab were inactive during daylight hours. Eight females were caged in late September and October 1980, but dissections showed 5 of 6 salvaged to have been unmated. The other was mated and deposited 90 fertile eggs (80J112.3) during a 12 day period beginning 3 days following confinement. Water was supplied, and

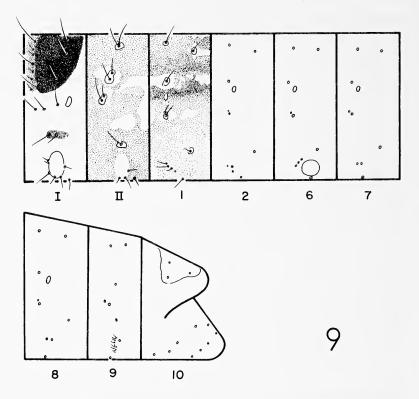


Fig. 9. Setal map of Ethmia heliomela. Shading depicts heavily marked form.

potential foodplants had flowers and aphids rendering copious honeydew, which may have been used by the females as nourishment. Unmated females survived 6-21 days ( $\bar{x} = 13.5, 7n$ ) in captivity and the gravid female 23 days, the first 4 in refrigeration.

Various plant samples were presented including Boraginaceae: native Cynoglossum australe R. Br., Ehretia acuminata) and exotic (Lithospermum prostratum Loisel., garden Myosotis, Echium vulgare L.); Scrophulariaceae: (Hebe diosmifolia R. Cunn., Veronica formosa R. Br. and V. calycina R. Br.); and Fabaceae (Westringia fruticosa Druce). None elicited oviposition response except by the one female, which was offered Lithospermum and Myosotis, to which Ehretia (drying) was added on day 2, and Veronica on day 5. The first 6 eggs, deposited on day 3 or 4, were placed on Myosotis and Lithospermum nested in plant hairs in the fashion characteristic of many Nearctic Ethmia (Powell, 1971). Nearly all subsequent eggs were poked into the nylon mesh, a substrate also preferred by captive ethmiids in California.

Only 19 eggs were produced up to day 11 of confinement at room

temperature (16 days following collection); 79% of the eggs were deposited in days 12-18, 22 of them (24% of the total) during the last night the female was alive.

Egg.—The eggs were cylindrical with rounded ends and had conspicuous chorion ridges arranged in parallel rows, similar to those of Holarctic Ethmia (fig. 3). Those deposited in nylon mesh ranged 0.69 X 0.36 mm to 0.73 X 0.45 mm in length and width and were about as thick as wide, varying in details of form with irregularities of their enmeshment. Eggs were white with a pearly sheen when fresh, turning yellowish during development, which required 10-11 days at intermittently cool room temperatures.

Larva.—Newly hatched larvae were offered various combinations of foliage terminals of Myosotis, Lithospermum, Echium, Cynoglossum, and Veronica, during a 15 day period. Several fed for a few days on leaves of Myosotis, where they were positioned against container sides, but available plant material was deteriorating, and none of the larvae reached the second instar. Buds and leaves of Lithospermum, Echium, and Cynoglossum were densely hirsute and appeared to present insurmountable physical barriers to unfed larvae. Repeated attempts to elicit feeding in open flowers or artificially opened buds, failed; this is the feeding site of several Nearctic Ethmia that depend upon hirsute borages (Powell, 1971).

Possible Hostplant Association.—Ethmia postica females were collected near Queanbeyan, N. S. W., on the southern tablelands near the A.C.T. border, Although I.F.B. Common had never taken this species during 9 season sampling at the site, 18 individuals (11 ♂, 7 ♀), mostly in fresh appearing condition, were collected during a 4 night sequence. As a result it was assumed that some locally growing native or introduced Boraginaceae must have been the source; Cynoglossum australe and Echium vulgare were the most likely suspects according to the A.C.T. Flora. Later, however, when I had summarized the distribution of E. postica (Powell, 1982) and compared records of Boraginaceae in the Herbarium Australiense, Halgania cyanea Lindl, emerged as a possible hostplant. This species, a low shrub of sand dunes and mallee scrub on sand, has a general distribution comparable to that of E. postica but is not known to extend east of the Great Dividing Range. Thus several peripheral southeastern records for E. postica are outside the range of this plant. Because these records are temporally sporadic, such as at Queanbeyan, at Black Mountain, A.C.T. (6 moths in Sept.-Oct., 1962, 1965, 1968 during a 15 year light trapping survey), and in southern Victoria (one specimen in the Gooding collection from Moe, where Gooding collected for many years), it is possible that they originate from passive movement of individual moths to cismontane areas from the interior via storm front airstreams. The likelihood of 18 individuals appearing at one MV light following such movement seems low, yet the fact that 5 of 6 females were unmated lends

credence to such a hypothesis. Normally female ethmiids are mated when attracted to lights, but it is well known that migrations of noctuids involve sexually immature adults (e.g. Common, 1954; Fox, 1978). Moreover, Fox has documented migration of many Lepidoptera across the Tasman Sea via storm front airstream movements to the southeast, particularly in October. While most of his records are for larger, strong flying moths and butterflies, the arctiid, *Utethesia pulchelloides* Hamps., seems to be weak flying to the human observer and also feeds on low growing Boraginaceae (McFarland, 1979). *Utethesia* was taken in numbers in New Zealand (9 specimens in one light trap, others at stations along a 400 km band of the west coast) during a 2 night period following passage of a front. Back trajectories calculated on meteorological data showed the likely origin of such moths to have been coastal southern Queensland or northern New South Wales 60 hours previously, a far greater distance than *Halgania*-associated insects would need to migrate to reach the Canberra area.

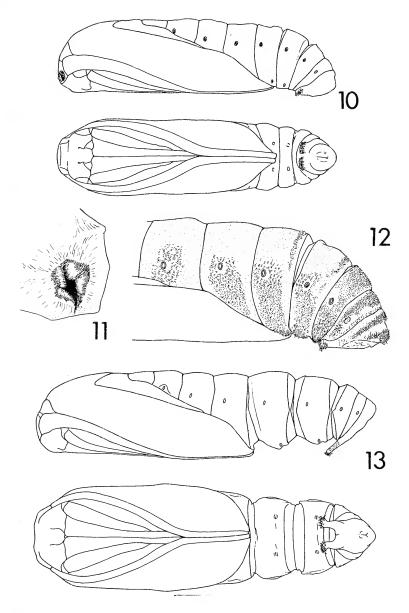
Collection data.—3 km NE Queanbeyan, N. S. W., 28 Sept. to 1 Oct. 1980 (MV light I.F.B. Common and J. Powell) (JAP80J112); same data 12 Oct. 1980 (80K124).

# Ethmia hemadelpha (Lower, 1903)

A northern species, *E. hemadelpha* is widespread from west central Western Australia to the coastal mountains of southeastern Queensland (Powell, 1982). It was reared in 1962 by K. T. Richards at the Kimberley Research Station, W. A., from *Ehretia saligna*. The foodplant record was reported by Common (1970), at that time the only known host of an Australian ethmiid.

Final instar larva.—Length 18.6-22.2 mm (2n). Head: HC width 1.57-1.62 mm. Setation as in other Ethmia (e.g., Mackay, 1972). Adfrontal sutures extending to cervical angle, adfrontal areas abruptly attenuated posteriorly. Pale amber colored, mottled with rust except in stemmatal area. Primary setal arrangements of thorax and abdomen as in fig. 8. SD1 directly dorsad and well separated from the spiracle on A1, anterodorsad and approximate to spiracle on A2-8. SD2 lacking on abdomen. Sclerotized depressions associated with spiracles or with thoracic leg setae lacking. Secondary setae lacking except a cluster of 4-6 translucent, fine setae anteroventrad of SV on A9 (apparently missing on one individual). D area white; SD mostly rust colored (on preserved specimens) with round, white spots. The raised pinacula darker: L area whitish below spiracle, which is included in rust blotch of SD pinaculum on A2-8; SV area lightly tinged with rust, V pale. Crotchets of abdominal prolegs in a mesal "penellipse" (ca. half circle), irregularly biordinal, 22-28; anal prolegs crotchets irregularly biordinal, 24-26.

Pupa (fig. 13).—Length 10.2 mm (1n). Head without projecting structure. Antennae and wings extending to posterior margin of A4. A5-7 movable by



Figs. 10-13. Pupal characteristics of Australian Ethmia: 10, E. sphaerosticha pupa, lateral (upper) and ventral (lower) aspects; 11, E. sphaerosticha, lateroventral portion of frons (dorsum at top), showing detail of antennal pit; 12, E. sphaerosticha, abdominal setation; 13, E. hemadepha pupa, lateral (upper) and ventral (lower) aspects.

deep intersegmental clefts and lateral condyles. Raised areas posterior to spiracles on A3-A6 bearing dense patches of short setae which extend below spiracles in slight depressions. Anal legs well developed, bootshaped, with dense clusters of hooked setae distally. A10 with a group of 6 blunt, nonhooked setae.

Collection data.—Kimberley Research Sta., W. A., 7 Oct. 1962, ex Ehretia saligna (K. T. Richards); associated reared adults examined.

# Ethmia nigroapicella (Saalmueller, 1880)

Originally described from Madagascar, nigroapicella is widespread in the Indo Australian and Oriental Regions, from Madagascar to the Seychelles, India, Burma and the islands of New Guinea, Philippines, Fiji, Samoa, Ryukyu, Formosa, and it is well known (as E. colonella Walsingham) in Hawaii, where it is presumed to be introduced. The species reaches the northernmost extremities of Australia, on the Wessel Islands and Cobourg Peninsula, N. T. and Sue Island in the Torres Strait, Queensland (Powell, 1982). The Australian specimens are smaller and display minor morphological differences from that reported elsewhere for nigroapicella, and confirmation of the assignment of populations on the northern islands to nigroapicella must await study of further material.

Foodplants.—A notable defoliator of Cordia subcordata Lam. and occasionally feeding on C. sebestena L. in Hawaii (Swezey, 1944; Zimmerman, 1978), nigroapicella is also recorded from Ehretia sp., deduced to be E. dicksoni var. japonica Nakai, by Sattler (1967), and from E. buxifolia Roxb. and Cordia in Japan (Moriuti, 1963). Fletcher (1933) recorded E. laevis Roxb. in India, and Cordia subcordata was listed as the host in the Seychelles (LeGrand, 1965). Among these Boraginaceae, Cordia subcordata occurs in the Australian areas where nigroapicella is known.

Larva.—The last instar larva has been described from Hawaii by MacKay (1972) and Zimmerman (1978). The full grown caterpillar is brightly colored, black with light yellow DL lines and irregular light yellow spots including the lateral row above the spiracles, and is characterized by numerous secondary setae in the D, DL, L and SV groups, particularly on the thorax, differing in this respect from the other Australian Ethmia described here.

Pupa (figs. 14, 15).—General aspects described by Zimmerman (1978), who included an outline drawing by MacKay of the ventral aspect. In order to compare more subtle features of setation and spiracles with the other species, the pupa is further characterized as follows:

Length 9.6-10.1 mm (2n). Head without projecting structures. Antennae and wings extended to proximal one third of A5. A5-7 movable by deep intersegmental clefts and lateral condyles. Spiracles of A3-A7 situated on irregular raised ridges, followed and subtended by dense patches of golden setae; A5-A7 sparsely setate on anterior half below the spiracular

patches, spiculate posteriorly (fig. 15). Anal legs well differentiated, tapering, with distal margin slightly broadened, bearing dense clusters of hooked setae. A10 without true cremaster setae.

Collection data.—Hawaii: Volcanos Natl. Park, Kamoamoa, 30 March 1981, r.f. Cordia subcordata (F. G. Howarth); associated reared adults examined.

# Ethmia thoraea Meyrick, 1910

A member of the Nigroapicella Group (Sattler, 1967; Powell, 1982), thoraea is related to several tropical rain forest species to the north. Its range, however, is broader than that of rain forests, from the north coast of Queensland to coastal N.S.W. in the Illawarra District, and inland at Cunnamulla, Q., and Mt. Kaputar, N.S.W. There are discrete spring and fall flights. Larvae of a related species, E. nigroapicella (Saal.) feed on Cordia and Ehretia in India, Japan and Hawaii (Sattler, 1967).

Adult behavior.—This and related species are believed to be strictly nocturnal, despite their brightly colored, aposematic-appearing hindwings and abdomen. One female confined in a petri dish lived 12 days during mid-January. She was fresh appearing and was suspected to be unmated after producing no eggs during days 1-4 in the presence of Ehretia (acuminata?) leaves from the Bunya Mts., Q. On day 5 a bouquet of Cynoglossum australe was added. During the next 4 nights she produced 38 eggs, all laid singly on the Cynoglossum, none on Ehretia. Most were deposited on unopened flower buds or in sepal cups containing young nutlets (60%), although an appreciable number were placed on undersides of leaves (29%); the remaining few were on leaf uppersides and stems. Most were nested in crevices around buds, where they were sometimes piled up, or among plant hairs, in the fashion characteristic of many Nearctic Ethmia (Powell, 1971).

Egg.—Eggs (fig. 4) were similar in shape and surface sculpture to Holarctic Ethmia, resembling those of E. postica in size, shape, and color. Chorion characteristics indicate closer relationship to E. heptasema, with a system of irregular cuneiform, rather than oval or rectangular segments. Eggs ranged 0.63-0.75 X 0.33-0.41 mm in length and diameter, varying with placement. Development was rapid, hatching occurring in fewer than 6 days.

Larva.—Newly emerged larvae failed to feed on buds, nutlets, or leaves of 6-day old Cynoglossum australe and escaped from a faulty container before other plant material could be provided.

Failure of *Ehretia* to elicit oviposition, together with the precise selection of hirsute *Cynoglossum* buds suggests some Boraginaceae other than *Ehretia* is the normal host plant, despite the fact that most collection records are from rain forest localities.

Collection data.—Mt. Tamborine, Q., 10 Jan. 1981 (MV) (JAP 81 A114).

Ethmia heptasema (Turner, 1898)

This species differs markedly in genital characters from any other in the Australian fauna. According to genital structures, it appears to be most closely related to *E. heliomela*, a supposition enhanced by the oviposition behavior of the two. *E. heptasema* occurs in rain forests of coastal mountains from central Queensland to the Illawarra District, N. S. W., and there are possibly conspecific specimens from New Guinea (Powell, 1982).

Adult bheavior.—The moths are nocturnal. Most collections have been made at lights, and E. heptasema has the largest eyes of any Australian Ethmia, with an eye index above 1.0, indicative of nocturnal behavior in Nearctic species (Powell, 1973: 8). Four females were confined in 2 petri dishes during a 15 day period in mid-January. Leaves of Ehretia (acuminata?) from the Bunya Mts., Q. were provided. About 250 eggs were produced, and females exhibited different preferences for oviposition sites. In one dish one or both moths deposited 28 eggs, 26 of them in axils of the raised underside leaf veins where they nested against small tangles of plant hairs (fig. 5). In the second dish the females deposited 222 eggs, mostly on leaf edges (57%) or in the damp cotton wick (36%). A few were placed on glass sides of the container, none on leaf vein axils.

Although a few eggs were isolated singly in each dish, most were deposited in small, irregularly assembled clusters of 3-9 eggs. Egg clutches placed in leaf vein axils ranged 1-4 per site ( $\overline{x}=2.4,11n$ ) (fig. 5); those on leaf margins often were aggregated into larger clusters, often composed of eggs of different ages, indicating retrn visits to the sites on successive days. Isolated clutches of uniform age on leaf margins and container walls consisted of 2-9 eggs ( $\overline{x}=4.5,8n$ ). Females displayed selection preference for aggregation of eggs once a cluster was started, with most of the available leaf margins remaining unused. As many as 10-13 eggs may have been deposited at once in the larger batches, judging from age groups.

Eggs.—Individual eggs were cylindrical, resembling typical Holarctic Ethmia eggs in shape but not chorion sculpture, which was an intricate system of cuneiform segments (fig. 6). Those in clusters varied in form with placement. Eggs of  $E.\ heptasema$  were unusually small; isolated eggs ranged 0.57-0.62 X 0.35-0.38 mm in length and diameter. Differing stages of development were easily detected because the white eggs turned yellow within 24 hrs, then reddish orange by 48-72 hrs and began to show mandibular spots within 110 hrs. Hatching occurred in fewer than 6 days despite intermittent transport in a field ice box.

Larva.—Newly hatched larvae were provided with mature Ehretia leaves which were beginning to deteriorate after storage 5-8 days without consistent refrigeration. The final larvae to emerge were placed on fresh Cynoglossum australe, but no feeding took place on either plant.

Nonetheless, the geographical distribution of Ethmia heptasema, the

strong oviposition response to *Ehretia*, and the precise selection of sites on the leaves, suggests that *Ehretia acuminata* is the normal hostplant. Possibly mature leaves pose physical barriers to feeding by first instar larvae, and buds or new leaves are requisite to larval establishment.

Collection data.—Mt. Tamborine, Q., 4 Jan. 1981 (MV, b1) (JAP 81A103).

# Ethmia heliomela Lower, 1923

Ethmia heliomela is a small, brightly colored moth unlike any other Australian ethmiid. By structural features it appears to be related to E. lapidella (Walsingham) of India and the Orient, a species that superficially resembles E. heptasema. Ethmia lapidella has been reported to feed on Ehretia dicksoni var japonica Nakai and "soongroo (wild Salvia)" (Fabaceae?) (Fletcher, 1920: 133; Sattler, 1967). The latter record may have been based on a misidentified plant or a wandering full grown larva. E. heliomela is known only from eastern montane and coastal rain forests, from southern Queensland to southern N. S. W.

Adult behavior.—The orange and black hindwings and abdomen and relatively small eyes (eye index 0.90-0.95), give this species the appearance of a diurnal moth. The adults commonly fly to lights, however, so it is presumed to be primarily nocturnal. I found adults perched on Ehretia foliage in late afternoon and early morning. Under laboratory conditions, activity consistently took place during afternoon hours, but neither mating nor oviposition was observed. A freshly emerged male and female were caged in mid-November, but they survived only two days in unseasonably warm weather. Dissection showed the female unmated (80L38). Five females collected from foliage of Ehretia acuminata were individually confined in 42 X 60 mm plastic vials with branchlets of Ehretia inflorescences in bud to early bloom. These moths survived only 2-5 days. Two females deposited 11 and 23 eggs, either singly (62%) or in pairs or clusters of 3 or 4; usually laid side by side. All were placed on walls of the containers.

Egg.—The eggs resembled those of E. heptasema (fig. 6) in shape and chorion sculpture viewed at  $50 \mathrm{X}$  magnification. They measured  $0.61\text{-}0.65 \mathrm{x}$   $0.35 \mathrm{mm}$  at the rectangulate-oval base of attachment and were ca.  $0.25\text{-}0.30 \mathrm{mm}$  thick. During development the eggs turned pale yellow within 12 hrs, then pink within 48 hrs. Hatching occurred in ca. 10 days.

Larva.—No attempt was made to feed newly hatched larvae, but caterpillars of the penultimate and at least 2 preceding instars were found in conspicuous webs in inflorescences of *Ehretia*. Quite small larvae produced copious silk networks encompassing branchlets several cm apart. Sometimes 2 larvae occupied one web, but they were not colonial, living individually except where abundant. At Mt. Keira only in the final 2 instars were larvae found to feed on leaves, usually by extending webbing

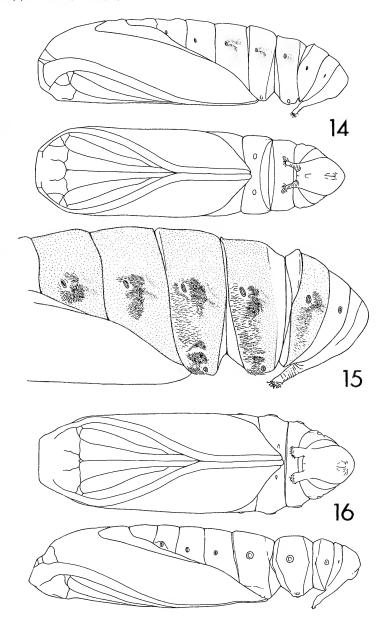
from wilted inflorescences onto subtending leaves where they skeletonized the upper surface. Timing of oviposition seemed to be related to that of flowering; young larvae were collected November 26 from trees in bud to early bloom, but another tree with buds just starting to develop had none. Three weeks later David Walsh observed webbing and larvae on the latter tree and on Dec. 22 I found larvae of the final 3 instars on its inflorescences in late bloom. In the laboratory late instar larvae fed on leaves after inflorescence material had been consumed.

Final instar larva.—Length 15.8-16.8 mm (5n). Head: HC width 1.22-1.26 mm. Setation as typical for genus (e.g. MacKay, 1972). Adfrontal sutures reaching cervical angle, adfrontal areas abruptly narrowed posteriorly. Black to dark amber brown, conspicuously contrasting pale bands flanking adfrontals and longitudinally on venter, beneath stemmatal area. Primary setal arrangements of thorax and abdomen as in fig. 9. Prothorax with strongly delineated shield, black narrowly edged with amber to mostly amber blotched with blackish; 5 secondary setae along its anterior margin on each side; D1 and D2 widely separated. Sclerotized depressions associated with spiracles or with prothoracic legs absent. L2 tiny on A1-8. Secondary setae absent except a row of 6 or 7 anterior to SV on A9. Color pattern variable, mostly dark olive green (appearing black on living caterpillars), as in fig. 9, with pale bands narrowly at mid-dorsum and of irregular spots longitudinally in SD, L areas (tan or pale greenish in life); a separate color phase has the dark markings restricted, lacking from posterior ½ or ½ of each segment so that the larva has segmental, transverse pale bands. Pinacula sclerotized, dark brown, darker above spiracles. Crochets of abdominal prolegs uniordinal but varying in size, 30-34 in a circle, of anal prolegs, 34.

The larval color phases appeared to be discrete, without a gradation of intermediates, in the last instar, but they could not be separated in early instars. Penultimate and antepenultimate instars were similarly patterned to the fgl but were paler. The banded form, segregated as a sublot (80M30.1), produced normal E. heliomela adults. One larva, perhaps teneral, was observed that appeared orange with pale cream longitudinal bands to the unaided eye. It too was separated (80M30.2) and produced E. heliomela.

Evidently this species is capable of developing dense population levels, during which larval feeding is not restricted to inflorescences. Larval webbing encompassed an entire *Ehretia* tree near Jamberoo, N. S. W. in May 1980 according to D. S. Stevens (in litt. to I. F. B. Common). His photographs show strings of larvae festooning the defoliated tree. It is possible that other Lepidoptera were involved, but only *E. heliomela* was reared, from cocoons in the bark of a silk-covered piece of a large branch.

I did not discover a pupation site in the field but in or under loose bark may be normal. In the laboratory cocoons were plastered onto paper



Figs. 14-16. Pupal characters of Australian Ethmia: 14, E. nigroapicella pupa, lateral (upper) and ventral (lower) aspects; 15, E. nigroapicella, detail of abdominal sculpture and setation; 16, E. heliomela pupa, lateral (upper) and ventral (lower) aspects.

towelling incorporating debris, on paper under flat cardboard or in lumens of corrugated cardboard, and once in a curled dry leaf.

Pupa (fig. 16).—Length 6.8-7.6 mm (5n). Head truncate, square-margined ventrally. Antennae and wings extending beyond A4, nearly across A5. Intersegmental areas preceding A6 and A7 deeply cleft dorsally and ventrally, movable by lateral condyles. No setaceous areas. Spiracles of A5, A6 huge, ca. 2X diameter of those on A2-4 and 7; A8 sp absent. Anal legs well developed, variable in shape, separation, and angle of projection; bearig a series of short hooked spurs distally. A10 without setae representing the true cremaster.

The enlarged spiracles of segments 5-6 and loss of spiracle on 8 are unique among described Ethmiidae and perhaps all Lepidoptera. According to Mosher (1916: 29) spiracles are always present on abdominal segments 1-8 in Lepidoptera, although those of the 8th are never functional and show no distinct opening.

Under laboratory conditions development time of pupae varied. Although feeding ceased within 10 days, emergences occurred 18-30 days following collection of larvae in both November and December, and continued sporadically up to 80 days. Material collected at Jamberoo in May produced adults in August and again in November, indicating that diapause occurs in the pupa and termination is facultative in response to environmental cues, as is known in Holarctic *Ethmia* (Powell, 1973: 40; 1974).

Voltinism.—Collections of adults indicate a flight period from October to February, but 80% of the records are in spring, primarily November and early December. In New South Wales, only 3 (12%) of the collections were made in January and February, suggesting that a summer generation is facultative and relatively rare, as indicated by sporadic emergences in laboratory conditions. At Mt. Keira, in 1980 I collected both adults and larvae in late November and again 4 weeks later but could find neither in early February. Thus it is likely that  $E.\ heliomela$  normally undergoes two generations in spring and early summer and occasionally emerges later, particularly if Ehretia blooms sporadically and the moth's ovipositon is cued to the same factors that influence inflorescence development.

Natural enemies.—Although many larvae were collected, most of those not preserved became diseased prior to maturing, probably the result of suboptimal conditions in the lab. Among 17 individuals reared to maturity, only one was parasitized. A tachinid emerged within 23 days of the larval collection after pupation inside a heliomela cocoon, before pupation of the host larva.

Collection data.—Jamberoo, N. S. W. May 1980 (D. S. Stevens), adults emgd. Nov. 1980 (JAP80L38); Mt. Keira, Wollongong, N. S. W., 25/26 Nov. 1980, adults (80L46), larvae (80L47) on *Ehretia acuminata*; same data 22 Dec. 1980 (80M30).

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Assembly of specimen data and mapping of distributions were carried out by Elizabeth Randal. Cooperation by Lesley Lockwood and authorities of the National Botanic Garden and Herbarium Australiense, CSIRO enabled use of living plant samples and of collections in their care.

David Walsh, caretaker of the Mt. Keira Boy Scout Camp, Wollongong, N. S. W., provided facilities and botanic expertise making possible several collections that were critical to the study. Discoveries of ethmiids at Mt. Keira and elsewhere by Victor J. Robinson provided much of the background information for my taxonomic and biological work.

K. T. Richards, Dept. of Agriculture, Perth, W. A., loaned larval and pupal specimens of *Ethmia hemadelpha*, and F. G. Howarth and G. M. Nishida, Dept. Entomology, Bernice P. Bishop Museum, Honolulu, provided pupal shells of *E. nigroapicella*, enabling inclusion of their descriptions.

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# Field Study of *Phyciodes batesii* (Reakirt) and *P. tharos* (Drury) from a Site in the Black Hills, South Dakota (Lepidoptera: Nymphalidae: Melitaeinae)<sup>1</sup>

Clifford D. Ferris<sup>2</sup>

Bioengineering Program, University of Wyoming, Laramie, Wyoming 82071

**Abstract.** Maculation and male genitalic structure are discussed for two sympatric populations of *Phyciodes* at a study site in the Black Hills, South Dakota. Evidence suggests naturally occurring hybrids.

#### Introduction

In a recent publication (Ferris & Brown, 1981), Ferris alluded to a problem in identifying certain species of *Phyciodes* from the Black Hills, South Dakota. Data presented by Oliver (1979, 1980) concerning his studies of *Phyciodes batesii* (Reakirt) and *P. tharos* (Drury) now make possible relatively easy separation of these two species.

To summarize Oliver's findings (1980), two separate forms of *P. tharos* exist, which he has designated as types A and B. Type A is mutivoltine; type B is univoltine. According to Oliver, in the western United States, type B, generally designated as *P. tharos pascoensis* Wright, is found above 8000' (2440 m), while type A is found in moist canyons below 7000' (2135 m). He reported that both types are sympatric in the Black Hills.

Oliver has also indicated (in litt.) that the ventral color of the antennal clubs can be used in some instances to separate tharos types A and B. Where applicable, the color in A is black or dark gray, while it is orange or yellowish in B. In northern plains populations, however, light-colored antennal clubs are a fixed character. Here types A and B are best separated by voltinism and the size and extent of the dorsal dark markings in the males. Type B specimens manifest broad dark wing borders.

My studies were conducted in a side canyon perpendicular to Little Spearfish Creek Canyon (shown on some maps as Tinton Creek Canyon), just behind the Timon Campground, Custer National Forest, Lawrence Co., South Dakota, 5700' (1740 m). *Phyciodes* populations in this area

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<sup>&</sup>lt;sup>2</sup>Research Associate: Allyn Museum of Entomology/Florida State Museum, Sarasota, Florida; Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, Florida; Department of Entomology, Los Angeles County Museum of Natural History, Los Angeles, California.

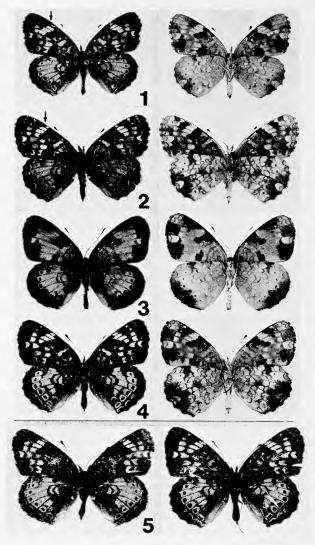


Fig. 1. P. batesii (male) from Black Hills study site, 22 July 1973, dorsal left, ventral right.

- Fig. 2. P. batesü (female) same data, dorsal left, ventral right.
- Fig. 3. P. tharos type B (male) from Black Hills study site, 22 July 1973, dorsal left, ventral right.
- Fig. 4. P. tharos type B (female) same data, dorsal left, ventral right.
- Fig. 5. Melanic females of P. batesii (left) and P. tharos type B (right) from Black Hills study site; tharos collected on 22 July 1973; batesii collected on 27 July 1977.

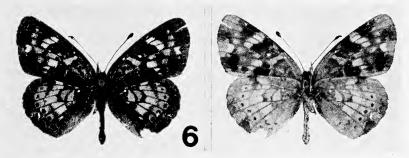


Fig. 6. Possible hybrid male P. batesii X tharos type B from Black Hills study site, 22 July 1973, dorsal left, ventral right.

were sampled in 1969, 1970, 1973 and 1977.

At this study site, I have found only tharos type B and batesii on the wing during the month of July, the time of year I have visited this area. Based upon my field experience, tharos type B appears to predominate in the Rocky Mountain region, from northern New Mexico northward into Alberta and British Columbia.

The antennae of *P. batesii* have ventrally black tips. This permits rapid separation of the two species when *batesii* is sympatric with type B *tharos*. Males of the two species are relatively easily separated based upon dorsal maculation. *P. batesii* is generally much darker overall than *tharos*, with heavy black scaling. It also has a two-tone appearance owing to the light color of the postdiscal band (indicated by the pointer in Figs. 1 & 2). The females are not so easily separated based upon maculation, particularly when they are somewhat melanic, as shown in Fig. 5. The females of both species have a two-tone aspect dorsally, which in *tharos* sometimes approximates *P. pratensis* (Behr). Generally, *batesii* females have a bright aspect with sharply defined maculation, while *tharos* tends to have a blurred appearance.

As noted by Oliver (1979), tharos and batesii have achieved similar phenotypes, but through different genetic means, as his hybridizational studies have shown. Natural hybrids are apparently rare. Laboratory studies indicate strong behavioral isolating mechanisms during courtship.

Five field-collected specimens, three males and two females, from the Black Hills exhibit hybrid characteristics. All five have type B tharos antennae (orange tip color ventrally). The three males resemble batesii dorsally. Ventrally one resembles tharos; the two others batesii. These latter two bear a fairly close resemblance to the hybrid specimen illustrated by Oliver (1979, Fig. 1c). One of these specimens is shown in Fig. 6. Black Hills batesii differ significantly in phenotypic appearance from the New York state population used by Oliver in his breeding studies (op. cit.). Consequently, one would expect possible batesii X tharos

hybrids from the Black Hills to differ somewhat in appearance from crosses between individuals from eastern populations.

The two females dorsally are intermediate with regard to the Black Hills populations studied. Ventrally they are pale, and not nearly so heavily marked as is typical tharos. Four of the specimens show no structural abnormalities of the abdomen as described by Oliver for laboratory hybrids. The remaining specimen, the first male described above, has a very contorted abdomen, but under the microscope it cannot be ascertained clearly if this results from a structural defect, or is simply an artifact of field handling and subsequent desiccation.

#### Genitalic Studies

There are differences in the male genitalia between tharos and batesii. The key structures are the horn-like processes extending from the posterior of the last tegumen (uncus). Fig. 7A depicts typical type B tharos from the Black Hills. Note the squarish aspect of the overall structure. Fig. 7B illustrates batesii from the Black Hills. The overall structure here presents a rounded aspect with a more acute angle at the base of the processes than occurs in type B tharos.

The three possibly hybrid males noted above have genitalia of the form shown in Fig. 7C. This structure is intermediate between those shown in Figs. 7A, B.

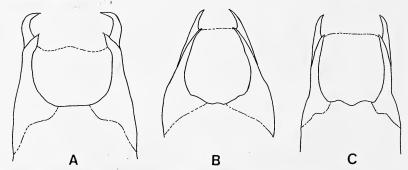


Fig. 7. Diagnostic portion of male genitalia of P. tharos type B and P. batesii. A. P. tharos type B. B. P. batesii. C. Apparent P. tharos X batesii. Genitalia from specimen shown in Fig. 6.

#### **Results and Conclusions**

On the basis of genitalic characters, it appears that the three males described above represent natural hybrids batesii X tharos type B. The two females remain enigmatic since the genital structures in that sex are not diagnostic.

The apparent hybrid specimens were collected accidentally and at random. They were not discovered until recently when the author revised

the arrangement of  $\it{tharos}$  and  $\it{batesii}$  in his collection based upon Oliver's studies.

Analysis of collecting records indicates that 90 males and 27 females of tharos, and 9 males and 6 females of batesii, with the additional five apparent hybrids were collected in the study region. Of this total number, 44 males and 16 females of tharos type B, and 8 males and 5 females of batesii were collected on 22 July 1973. Type B tharos is clearly the predominant Phyciodes at the study site, and perhaps accounts for the apparent hybrids. Not all Phyciodes observed, however, were collected. Hence the true ratio of tharos to batesii may not be represented by the numbers given.

The study site reported in this paper is on the eastern slope of the Black Hills. In July 1982, type B tharos and batesii were taken sympatrically on the western slope in the Black Hills National Forest, Crook Co., Wyoming.

Also in July 1982, these two species were found flying together in Monroe Canyon, 4400' (1340 m), Sioux Co., Nebraska (Pine Ridge region). Males of both species were taken at mud along the banks of a small stream. To date, no natural hybrids have been found in this area, but only limited numbers of the two species have been collected.

Acknowledgments. I would like to thank Dr. Charles G. Oliver for reading and commenting on two preliminary drafts of this paper, and for providing information on the genitalic structures in *Phyciodes*. Dr. Robert J. Lavigne of the University of Wyoming provided some of the specimens from the western slope of the Black Hills. An anonymous reviewer also commented on the manuscript.

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## Notes

# An Aberration of Glaucopsyche lygdamus (Lycaenidae) with a Complete Scolitantidine Dorsal Pattern

On 8 April 1982 I took a female Glaucopsyche lygdamus incognitus Tilden at Rancho Cordova, Sacramento Co., California, displaying an extensive dorsal pattern of black spotting on a blue ground, reminiscent of the normal pattern of several Palaearctic genera such as Maculinea. Females of this population are normally black with more or less blue basally, and the aberration (Fig. 1) is much more extensively blue than is commonly seen. Ventrally, the postmedian spot-band is enlarged and slightly distorted and the ground-color somewhat darker than average. No abnormalities were observed in a sample of about 20 animals examined and released at the site.

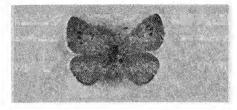
The resemblance to *Maculinea* and other Scolitantidines is extremely suggestive of homology. Mattoni (1981, The Scolitantidini. II. The world's smallest butterfly? Notes on *Turanana*, and a new genus and species from Afghanistan (Lycaenidae). J. Res. Lepid. 18:256-264) gives the occurrence of the dorsal pattern in several taxa of the genera *Micropsyche*, *Turanana*, and *Glaucopsyche*. According to Mattoni (in litt.) it occurs in some *Turanana*, *Micropsyche*, *Phengaris*, *Shijimiaoides*, and *Philotes* (sonorensis); in *Shijimiaoides* it is limited to females, as in *Maculinea alcon*. The genus *Caerulea*, which seems more closely related to *Glaucopsyche* than is *Maculinea* according to Mattoni, lacks the pattern (but cf. Higgins, 1975, *The Classification of European Butterflies*. Collins, London. 320 pp. [pp. 131-133]). Whatever the proper relationships within this group, the genetic control of the pattern is apparently labile, with more than one reversal or parallelism necessary in their history.

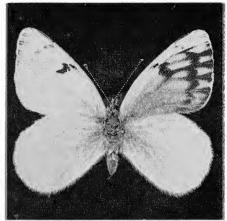
A similar aberration in female *Glaucopsyche melanops* has been reported by Chapman (1905, Trans. Ent. Soc. Lond. 53:ii-iii), who also noted the similarity to *Maculinea. G. melanops* is quite a distinct species of *Glaucopsyche*, and morphologically stands apart from the other six or so species in that genus. Chapman named the aberration var. "wheeleri," on the basis of two specimens from Digne.

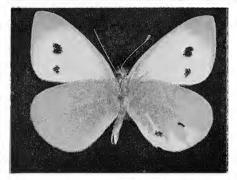
Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

# A Reared Gynandromorph of Tatochila (Pieridae)

On 2 April 1981 a mosaic gynandromorph emerged in a laboratory culture of the Tatochila sterodice Stgr. species-group, derived from Argentina (Pieridae). The specimen (Fig. 2) is an F<sub>1</sub> hybrid of T. s. sterodice male, ex San Martin de los Andes, Province of Neuquen, and T. vanvolxemii Capr. female, ex Bahia Blanca, province of Buenos Aires. It was reared without diapause under 10 hours light, 14 dark, day and night temperatures  $75^{\circ}F=23.9^{\circ}C$  and  $55^{\circ}F=12.8^{\circ}C$  respectively.







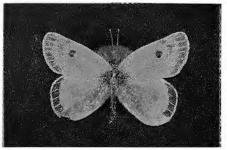


Fig. 1. Aberration of *Glaucopsyche* lygdamus.

Fig. 2. Reared gynandromorph of Tatochila sterodice x vanvolxemii hybrid, upper and under surface. See text. NOTE: Fig. 2 (only) is reversed due to a printing error.

Fig. 3. Reared homoeotic male Pieris rapae, stock ex Xochimilco, Mexico. Note FW tissue on one ventral HW (see text).

Fig. 4. Wild "intersexual" Colias eurytheme, upper and under surfaces; note "feminization" of dorsal FW pattern.

The body and three wings are completely male. The left forewing is mosaic above and entirely male below. Its upper surface is about 85% female; the male area occupies the costal margin down to vein  $M_1$ , with a mixture of male and female scales in interspace  $M_1$ - $M_2$  marginad of the dark submarginal band. The outer margin is slightly convex on the mosaic wing, a female character. The shape of the submarginal band on the female surface is slightly abnormal.

This is the only sexual mosaic produced in a complex hybrid culture of some 7000 butterflies reared over 18 months. Another F<sub>1</sub> brood produced a bilateral male-male mosaic, presumably resulting from a doubly-fertilized binucleate egg (Shapiro, 1982, Experimental studies of the evolution of seasonal polyphenism. In R. Vane-Wright and P. Ackery, eds., The Biology of Butterflies, Symp. Royal Ent. Soc. of London, in press).

Sibatani's (1980, Wing homoeosis in Lepidoptera: a survey. Devel. Biol. 79:1-18) analysis of 44 published gynandromorphs shows that sexual mosaicism is commoner on the fore- than the hindwings and on the dorsal than the ventral surface; there is no right-left difference. Of 19 Pierid gynandromorphs, 13 were confined to the dorsal surface, 1 to the ventral, 5 mixed. Thus, this individual is of the statistically commonest type of mosaic gynandromorph. It is very close to a ¾ male-¼ female individual, but the presence of male tissue on the aberrant wing suggests the chromosome accident occurred early in the history of the wing primordium but subsequent to the second zygotic division, which would give a neat ¼ picture.

Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

# Two Homoeotic Pieris rapae of Mexican Origin (Pieridae)

"Homeosis" was defined by Pennak (1964, Collegiate Dictionary of Zoology. Ronald Press, New York. 583 pp.) as "transformation of one organ into another by mutation...occurrence of an homologous appendage on a segment where it does not normally occur." In Lepidoptera, transformations of entire organs are virtually unknown, and the term, now usually spelled "homoeosis," refers to the patchy conversion of areas on the wings into areas appropriately placed on a different wing or on the other wing surface. Recognition of this condition depends on pattern differences which render the inappropriately-placed areas conspicuous. It seems to be very rare; most recognized examples have probably been published, and a majority figured. Sibatani (1980, Wing homoeosis in Lepidoptera: a survey. Devel. Biol. 79:1-18) reviewed 164 cases and presented statistics on the topology of the transformations.

A homoeotic male *Pieris rapae* L. (Pieridae) eclosed 19 June 1982 in the first generation of a laboratory stock established 5 March 1982 from several females collected at Xochimilco, Distrito Federal, Mexico, the southernmost known population of *P. rapae* in the Americas, for photoperiodism studies. The aberration was reared under 10L:14D with day and night temperatures of 70°F=21.1°C and 40°F=4.4°C, and did not diapause. It is shown in Fig. 3. It is similar to a homoeotic male *P. brassicae* L. figured by Gardiner (1963, Genetic and environmental variation in *Pieris brassicae*. J. Res. Lepid.2:127-136 [p. 134]) in having part of one ventral hindwing converted into ventral forewing. Because of the rearing regime, the

ventral ground color is bright yellow and the white converted area is easy to delimit. It contains both of the black ventral forewing discal spots in their proper interspaces. The entire homoeotic area is posterior to Sibatani's M<sub>1</sub>-M<sub>2</sub> barrier. All other wings and surfaces are apparently normal.

On 17 August 1982 a homoeotic female emerged in the same culture. This individual, shown alive in Fig. 5 (black and white) as it was to be bred, was reared under 10L:14D with day and night temperatures of 75°F=23.9°C and 55°F=12.8°C, and diapaused. It was from the same generation as the first; as noted, the culture was started by pooling the ova of several wild females, but it seems very likely that the two homoeotic individuals are full sibs. The converted area is nearly identical to that on the male, and like it the abnormality is confined to the ventral left hindwing. To date (early September 1982) no further aberrations have appeared in a total of some 570 animals examined from this culture, reared on several regimes.

Gardiner (loc. cit.) reported a cluster of three homoeotics deriving from a single mating involving hybridization of typical brassicae with subspecies cheiranthi Hbn. from the Canary Islands. All were males. One was sib mated and the line inbred for three generations, but no additional homoeotics appeared in a total of some 900 progeny. As our Mexican rapae line is to be continued for some time and diapausing members of the first generation are still in cold storage, every effort will be made to investigate the presumptive genetic predisposition to homoeosis. The extraordinary

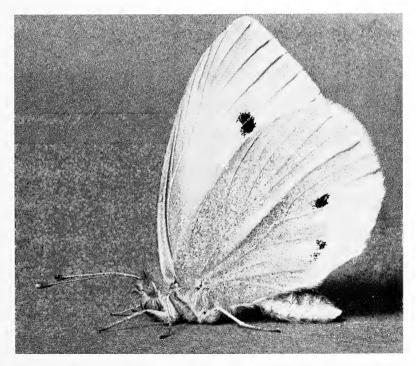


Fig. 5. Reared homoeotic female P. rapae from Xochimilco, photographed alive by S. W. Woo.

rarity of two homoeotics appearing in the same brood is underscored by their being the first and second homoeotic butterflies I have observed in over 20 years of collecting and breeding, including the rearing of perhaps a quarter of a million Pieridae for physiological and ecological studies.

Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

# An Apparent "Intersexual" Colias eurytheme (Pieridae)

In most Nearctic Colias species, the female forewing has a broad dark marginal band enclosing spots of the ground-color while the band on the male is continuous, narrow, and interrupted only by ground-color along the veins, if at all. This difference does not hold in some Palearctic species, in the circumpolar C. nastes Bdv., and in some South American species.

A C. eurytheme Bdv. showing a partial "feminization" of a male pattern was taken 18 February 1982 at Rancho Cordova, Sacramento Co., California. The specimen (Fig. 4) is genitalically male. The dorsal forewings have a double dark band enclosing the light ground color, in this regard resembling late winter-early spring females. Ventrally there are non-sexual anomalies: the forewing discal spots are divided or doubled like those on the hindwing, and there is a rudimentary accessory discal spot basad of the actual, doubled one on the right hindwing. The shape of the forewings is abnormal, and the flight of the animal was very low and direct, just above the ground.

Well-developed male examples of the winter-spring form "ariadne" of C. eurytheme occasionally show a very slight development of the inner dark band just below the dorsal forewing apex, enclosing one small "spot" of ground-color anterior to  $R_3 + 4$ . The Rancho Cordova specimen seems to represent an extreme manifestation of this tendency in which the developmental control mechanism which normally inhibits the inner band in males failed to do so. This may or may not be attributable to abnormalities in the sex-determination mechanism. Although the relationship between the male and female patterns in Colias could be interpreted in two ways, the general rule that reduction is "easier" than complexification in evolution suggests that the normal eurytheme male pattern is a reduction from the female, and thus evolutionarily derivative. The present aberration would then be considered reversional, or atavistic. If the Andean Colias (Colias) are monophyletic, either at least one reversal or one convergence or parallelism for this character has occurred, since the species flaveola Butl. and weberbaueri Stgr. are monomorphic or nearly so, the others sexually dimorphic for the forewing border.

Arthur M. Shapiro, Dept. of Zoology, University of California, Davis, CA 95616

# Two New California Catocala Subspecies (Noctuidae)

John W. Johnson

Assistant Research Biologist, Museum of Systematic Biology, University of California, Irvine, CA 92717

Abstract. Catocala andromache subsp. wellsi Johnson, with nearly black body and forewings, from Jackson, Amador Co., CA, and Catocala mcdunnoughi subsp. browerarum Johnson, with dark gray-brown body and forewings, the wings suffused with green scales, from Moore Creek Campground, Calaveras Co., CA, both localities in the northern Sierra Nevada Range, collected by R. E. Wells, are described, the types being deposited in the A. E. Brower collection, Augusta, Maine.

Catocala andromache (Hy. Edwards 1885) was described from a specimen from "near San Bernardino," California. Southern California specimens from Kern River Canyon in the southern Sierra Nevadas, the Santa Ynez Range in Santa Barbara County, to San Diego County are quite uniform with brownish-gray primaries, the maculation even, pattern lines distinct, and patches of green scales suffusing the wings in green, varying in the same locality from slightly green to nearly leaf green in fresh specimens, the green fading in aging outdoor specimens and in storage in light-proof cabinets. Catocala benjamini (Brower, 1937), described as an andromache subspecies, elevated to species rank (Brower, 1982), differs in smaller size (Johnson and Walter, 1978), paler coloration, absence of green scaling (Brower, 1937), in ovum scupturing, and in a larva unique from andromache from the first instar onward (Johnson, 1981).

Ralph E. Wells took two males and a female at Jackson, Amador County, California, that clearly represent a distinct northern California population of *andromache* of subspecific rank deserving recognition and description.

# Catocala andromache wellsi Johnson new subspecies

Holotype female: antennae dark gray, head, thorax grayish black with scattered yellowish-brown scales, fore and middle legs greyish black, rear legs lighter, abdomen proximally lighter, caudal two-thirds dark gray-brown; primaries above dark gray, nearly black, green scales suffusing the wings, line patterns obscured and in low contrast, t.a. line double, black, a black shade through the reniform spot to the posterior part of the t.p. line, t.p. line black, silhouetted outwardly by lighter scales, s.t. line black, subreniform spot pale gray, very conspicuous (not so in allotype). Lower surfaces much as in type subsp. but orange color more vivid, darker shades blacker, contrasts greater. Secondaries above yellow-orange, more vivid,

median black band strong, reaching inner margin black shading, inner margin black, fringe darkened, wing bases more heavily black scaled; lower surfaces more contrasting, orange brighter, dark areas blacker than in subsp. *andromache*. Forewing costal margin length 24 mm. Collected 19 June 1979 by Ralph E. Wells at ultraviolet light, Jackson, Amador County, California, 318 m elevation.

Allotype male: much as in holotype, antennae, legs, body grayish-black; primaries above grayish-black, patterns obscured, green scales suffusing the wings, subreniform spot inconspicuous; beneath darker, more contrasting than in type subsp. Secondaries above and below as in holotype, orange more vivid, dark areas blacker than in subsp. andromache. Length of forewing costal margin 23 mm. Collected 22 June 1977 at ultraviolet light, by R. E. Wells, Jackson, Amador County, California, 318 m elevation.

Holotype and allotype to be deposited in the A. E. Brower collection, Augusta, Maine. One paratype male, 16 June 1977, Jackson, Amador County, California, 318 m elevation, by R. E. Wells, in R. E. Wells collection.

Catocala andromache wellsi (Figure 1) is readily separable from subspecies andromache by the grayish black antennae, body, and nearly black forewings with low contrsts and obscuring of patterns, and the darker tones of the hindwings and under surfaces. All three specimens are much alike, the female holotype being blackest. Efforts to secure more specimens are continuing. Further search should discover the distribution of the subspecies in northern California. It is a pleasure to name the subspecies for its discoverer, Ralph E. Wells, an active and able field observer and collector of Lepidoptera for many years.

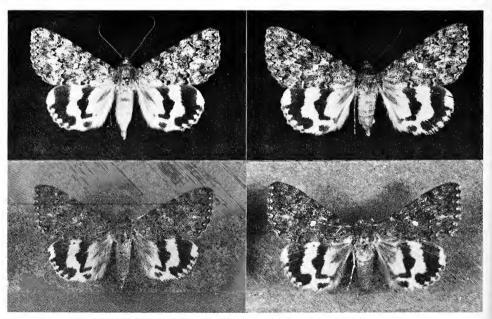


Fig. 1. Above: Catocala andromache andromache Hy. Edw., ♂ left, ♀ right. Below: Catocala andromache wellsi Johnson, ♂ allotype left, ♀ holotype right

# Catocala mcdunnoughi browerarum Johnson new subspecies

Holotype female: antennae brownish black, head, thorax, fore and middle legs very dark brown, with long, black, hoary-tipped setae, these forming a tuft at thorax dorsal caudal margin, and smaller tufts on abdominal segments 1 and 2 dorsa. Abdomen dark brown, paler anteriorly, ventrally dark gray brown. Pimaries above dark brown, contrasts in pattern reduced, the wings suffused with patches of green scales; wing bases dark brown, t.a. line strong, black, edged by light gray scales proximally, pale area between line and reniform spot less distinct, subreniform obvious, but darker; t.p. line strong, black, in less contrast with background, s.t. line narrow, medium gray, black bordered, wing submargin dark brown, intervein lunules dark, subdued; lower surfaces much as in type subspecies, contrasts in orange bands and dark areas greater. Secondaries much as in type subspecies, but orange more vivid and black bands, black scaling at wing bases and along inner margins stronger, outer margin lunules darker, apical white spot smaller; lower surfaces much as in species, somewhat darker and more contrasting. Forewing costal margin length 26 mm. Collected 15 July 1979, Moore Creek Forest Service Campground, Amador-Calaveras Cos., California, elevation 975 m, at ultraviolet light by R. E. Wells.

Allotype male: much as in holotype, antennae nearly black, head, thorax, fore and middle legs dark brown with long, black; hoary-tipped setae, tufted at thorax dorsal caudal edge and on dorsa of abdominal segments 1 and 2; abdomen dark brown above, paler anteriorly, gray-brown below; primaries above as in holotype, dark gray-brown, pattern lines black, in low contrast to background, reniform spot less obvious, subreniform reduced, marginal lunules heavily black outlined, fringes darker, wings with obvious green scaling; below darker, more contrasting than in type subspecies. Secondaries as in holotype, orange vivid, dark areas blacker, greater contrasts above and below than in types subspecies. Forewing costal margin length 25 mm. Collected 14 July 1979, at ultraviolet light, Moore Creek Forest Service Campground, Amador-Calaveras Cos., California, elevation 975 m, by R. E. Wells.

Holotype and allotype to be deposited in the A. E. Brower collection, Augusta, Maine. Two paratypes, males, 20 June 1981, 4 July 1981, Moore Creek Forest Service Campground, Amador-Calaveras Cos., California, elevation 975 m, by R. E. Wells, in R. E. Wells collection.

Catocala mcdummoughi mcdunnoughi (Brower, 1937) was named from a type series from Mount Lowe and Mount Wilson, Los Angeles Co., California. Throughout the southern California coastal mountains above 1524 m the species may be taken in woodlands containing Quercus chrysolepis Liebm. (Johnson, 1981). The southern California population is highly uniform, forewings predominantly brown, patterns of moderate contrast, and green sclaing never present. The four specimens taken by R. E. Wells differ strikingly from those of southern California in the grayish-black darkening of the brown coloration, reduced pattern contrasts, and the green scaling suffusing the wings. In northern California is present a previously uncollected and unrecognized population of subspecific rank (Figure 2). Efforts continue to secure more specimens and to explore the distribution of subspecies browerarum. The author is pleased to name this distinctive subspecies for the species' author, Dr. A. E. Brower, lifelong student of American Catocala, and Mrs. Lurana Brower, able assistant to her husband.

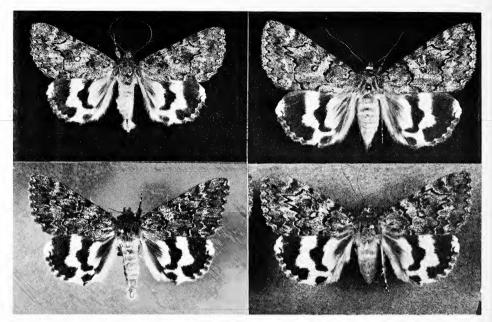


Fig. 2. Above: Catocala mcdunnoughi mcdunnoughi Brower,  $\sigma$  left,  $\varphi$  right. Below: Catocala mcdunnoughi browerarum Johnson,  $\sigma$  allotype left,  $\varphi$  holotype right.

Acknowledgments: Thanks are expressed to Mr. Ralph E. Wells for his generosity in permitting study of the specimens of the two subspecies and donation of the types to the A. E. Brower collection of the Smithsonian Institution, and to Mr. Gordon Marsh, Curator, Museum of Systematic Biology, University of California, Irvine, and his staff for assistance in securing references and in the typing of the manuscript.

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## Notes

# Notes on Maryland No. 10: Three New Butterfly Records for the State of Maryland

Three new butterfly species have been recorded for the state of Maryland as follows:

1. Atrytone palatka (Skipper), August 7, 1980, near Bucktown, Worcester County, Maryland.

The specimen was a worn male. It was collected near the town of Bucktown, on DeCourseys Road. The specimen was found in a sedge-like area which is typical of the habitat where we collect *Atrytone dion alabamae* Lindsey. The specimen was resting on one of the sedges. This area was further thoroughly investigated without success for other specimens. Along with the *A. palatka* were flying *A. d. alabamae*.

2. Lycaena epixanthe (Bog Copper), July 19, 1981, Garrett County, near Cherry Creek, near Bittinger.

For many years Robert Simmons has been seeking the Bog Copper, Lycaena epixanthe Boisduval and Leconte, in the cranberry bogs of western Maryland without success. On July 19, 1981, William A. Andersen and Philip Kean made a joint field trip to the mountains of western Maryland. North of Bittinger, Garrett County, they discovered a cranberry bog near Cherry Creek. Upon investigation of the cranberry plants, eight Bog Coppers were collected. This is the first record of the species in Maryland. The butterfly will undoubtedly be found in other cranberry bogs in Garrett County.

3. Ascia monuste (Great Southern White), September 3, 1980, near Newbridge, Worcester County, Maryland.

Bill Grooms and John Fales made a joint field trip to the Maryland eastern shore on September 3, 1980. Near Newbridge, Bill Grooms pulled his usual collecting stunt by netting a new species for the state of Maryland. Bill observed the specimen zig-zagging down the road and cruising off the road on both sides attempting to find a place to perch. The butterfly selected a large, fresh green leaf to alight and rest upon. Bill approached the specimen very carefully so as not to excite it. As he approached the specimen, he realized it was a worn male of the Great Southern White, Ascia monuste Linnaeus. Realizing this was a new species record for Maryland, he carefully secured the specimen. In his usual kind way he gave the specimen to John Fales for his Maryland studies of Lepidoptera.

We would like to thank Bill Grooms and John Fales for permission to report their records. A detailed citation of other Maryland records is given in the recent paper by Simmons and Andersen, 1978(1980), Notes on Maryland Lepidoptera No. 9: Seven new butterfly records for the state of Maryland. J. Res. Lep. 17(4): 257-259.

Robert S. Simmons, 8150 Loch Raven Blvd., Baltimore, MD 21204 William A. Anderson, 220 Melanchton Road, Lutherville, MD 21093 Philip J. Kean, 1215 Stella Drive, Baltimore, MD 21207

# Further Notes Regarding Colias hecla Lefebvre (Lepidoptera: Pieridae) at Churchill Manitoba

Ferris' recent comments concerning the occurrence of *Colias hecla* at Churchill Manitoba (J. Res. Lepid. 20(1):50-54, 1981(82)) are well taken. However, some additional information may be of interest to Ferris and other readers.

Since the 1974 season I have spent four additional seasons at Churchill conducting systematic studies of the butterfly populations in the Churchill region. With help from college students from the Churchill Northern Studies Center and others, population centers were mapped, and ecological and behavioral data recorded. This study covered additional areas not visited by Parshall and Oosting in 1974 or Ferris in 1973. The results of the study will be reported in a second paper now in preparation. With regard to the occurrence of *C. hecla* within the taiga areas, the following notes may present a clearer picture.

During the entire study only 35 adults were recorded. The year 1977 was by far its best with the author collecting 12 adults and fellow researchers together collecting an equal number, the greatest number ever recorded for any single season at Churchill.

 $C.\ hecla$  was always observed in association with tundra communities. It was never recorded closer than  $\pm$  75 meters to a forest-tundra ecotone. The species' ovipositing choices at Churchill are found in a few locations within the open-spruce forest ecotone referred to as "taiga" by some researchers. The open-spruce forest ecotone is really a mixture of both tundra and forest communites. Ferris' taiga reference may therefore be considered a tundra observation. Such biotope classification may help to clear the picture a little; in any case, Ferris' observations must be regarded as unique and not a data base for a theory for a taiga population of eastern  $C.\ hecla$ . Other researchers in the Eastern Arctic should systematically record flight patterns of  $C.\ hecla$  in their areas.

This author, as Ferris, has also collected *hecla* in the Western Arctic and the High Eastern Arctic. The Churchill population of *C. hecla* is more closely related to eastern populations than it is to western populations in terms of ecology, behavior, and total biology. Thus great caution should be exercised when eastern and western populations are compared, for the Western Arctic populations appear to represent a less stable genetic entity. Many factors may be altering the biology of the species in the Western Arctic. The possibility of sibling species within the *Colias* complex is just one of the several matters requiring careful research.

I look forward to reading Ferris' revision and hope that it will reflect careful biological research which will help answer some problems that exist with *hecla*. A literature review based on pinned specimens and the author's opinion will be of interest, but not nearly as useful as any biological insights.

I would like to suggest that terms such as *taiga*, *climax* and *sub-climax*, be dropped from use by lepidopterists when referring to Arctic and Sub-arctic biotopes. These terms do not reflect what is currently known about botanical communities in the arctic ecosystem. Besides not representing current ecological thought, the terms have a far too general meaning and do not help clarify a multi-dimensional research approach.

#### **Book Review**

Large White butterfly. The biology, biochemistry and physiology of Pieris brassicae (Linneus).

Feltwell, J. [et al.], 1981. Series ent. 18(1982): i-XXVI, 1-535. Dr. W. Junk Publishers, The Hague-Boston-London. Price: Hfl. 225.00/U.S. \$98.00

The scope of this monograph is so broad that to attempt a comprehensive critical review briefly could hardly result in a success. I therefore prefer a combination of a descriptive "book notice" with a critical "book review" of some selected parts of the book. J. Feltwell felt it necessary to engage three specialists to deal (alone or with himself) with certain topics: R. I. Vane-Wright (taxonomy), M. R. Shaw (parasitology) and H. D. Burges (pathology).

The work is divided into 18 main sections which are split further into numerous chapters. The main sections are: Nomenclature (1), Distribution (2), Life history (3), Foodplants (4), Breeding (5), Development (6), Morphology and Anatomy (7), Physiology (8), Hormones (9), Biochemistry (10), Migration (11), Senses (12), Economic importance (13), Parasitic control (14), Pathogenic control (15), Predators (16), Chemical control (17) and Integrated control (18). Preface (by M. Rothschild), Foreward, Acknowledgments, List of plates, List of tables and figures, Botanical specific names index, Zoological specific names index and Subject index complete the book. Comprehensive lists of references are given at end of each section, and there are 10 plates, 80 tables and 49 figures in text.

The book is very well bound in cloth (size ca. 16 x 24 cm) and printed on (unfortunately) glossy art paper which owing to its reflective properties makes reading especially in artificial light unpleasant. Matt paper, as used for the early volumes of Series entomologica would have been a significantly better choice, and perhaps cheaper, too. High technical quality of production has always been characteristic of the books published in this series, and the price usually expressed abundantly this aspect. In case of the volume under review, the price has surely overtaken the earlier standards. It surely is a great pity if a book of this kind is, because of its prohibitive price, eliminated from reaching many of its potential readers; or are the publishers particularly keen to provide good business for the manufacturers of photocopying equipment?

The first section deals with the taxonomy of *Pieris brassicae*, but is therefore somewhat inaccurately called just 'Nomenclaure'. It is written in part by Feltwell and Vane-Wright, partly by Feltwell alone. Some of the statements made in the section are both difficult to justify and to understand. The authors deal with 'subraces' and with numerous aberrations and other infrasubspecific forms. They follow B. O. C. Gardiner in their treatment of *P. cheiranthi* as subspecies of *P. brassicae* and do not seem to realize that they contradict their own concept by the inclusion of *P. brassicae azorensis* as a 'subrace' of their *P. brassicae cheiranthi*. In spite of the flood of infrasubspecific names discussed, there is no mention of an available name proposed for subspecies *Pieris cheiranthi benchoavensis* Pinker (1968) and Pinker's paper is not listed in the bibliography. The statements regarding the adult morphology seem to be based entirely on observations made by other authors and are incorrect in some applications (e.g. valva).

The section on 'Distribution' shows some gaps of considerable significance. Although countless reports of English collectors are cited on the absence or

occurrence of *P. brassicae* in countries they visited in the course of collecting of butterflies, many significant indigenous standard works dealing with the distribution of the species are left out; I name here just a few authors that I easily recall: Buresch & Tuleschkow, 1929-1943; Gozmany, 1968; Hruby, 1964; Korshunov, 1972; Krzywicki, 1962; Verity, 1947. Local faunistic monographs are only exceptionally cited. This results in avoidable inaccuracies, e. g. *brassicae* is stated to be absent from Crimea although listed by Korshunov (1972).

Sections on 'Life history' and 'Foodplants' are considerably better than the first two, though only a small proportion of data applies to wild populations. It would have been interesting to try to define the ecological factors that are decisive for the occurrence of the species and limit its distribution. Adult foodplants and preferences are not dealt with.

Sections on 'Development' and 'Breeding' deal almost exclusively with observations relevant to *brassicae* in captivity. The section on 'Morphology and Anatomy' lacks adequate illustrations of genitalia of both sexes and of androconia; the descriptions provided also leave much to be desired.

The section 'Predators' is probably the most complete account so far compiled on any butterfly species.

Bibliographical references and citation selected for a reference book of this type are particularly important for the reader. It is therefore most unfortunate that the bibliographies probably contain a much high proportion of errors than should be tolerated. About thirty minutes spent comparing some references selected at random produced the following list of major errors (small errors are not included here).

#### **Feltwell**

# Page Original

Schurian, K., 1975. Notizen an *Pieris* 24 cheiranthi. Ent. Z., Frankf.a.M. 85: 252-256.

Frankf.a.M. 85: 252-256.

Kurentzov, N. J., 1929

53 Kusnezov, N. J., 1929

Naumann, C. L., 1974. Immigrations 55 in Afghanistan 1972. Atalanta B 5: 82-88.

Naumann, C. M., 1974. Beobachtungen uber den Verlauf einer Lepidopteren-Immigration in Afghanistan 1972. Atalanta, Muennerstadt 5: 82-86.

Schurian, K., 1975. Bemerkungen

uber Pieris cheiranthi. Ent. Z.,

Schreiber, H. in Mueller, P. 1976. Der 56 Katalog der Ortlichkeiten im Bundesrepublik Deutschland. Vol. 2. Lepidoptera. Schreiber, H. 1976. Fundortkataster der Bundesrepublik Deutschland. 2. Lepidoptera.

To summarize the observations made in this very brief, and necessarily perfunctory, review, it can be said that the publication of the compilation on *Pieris brassicae* was in principle a very good idea. The same implies to the choice made by the author. That the author had not asked selected specialists to read final drafts of each section resulted in the book being only a qualified success. The amount of work Feltwell put into this book would have been worth the 'last touch of perfection'.

# INSTRUCTIONS TO AUTHORS

Manuscript Format: Two copies must be submitted (xeroxed or carbon papered), double-spaced, typed, on  $8\frac{1}{2}$  x 11 inch paper with wide margins. Number all pages consecutively and put author's name at top right corner of each page. If your typewriter does not have italic type, underline all words where italics are intended. Footnotes, although discouraged, must be typed on a separate sheet. Do not hyphenate words at the right margin. All measurements must be metric, with the exception of altitudes and distances which should include metric equivalents in parenthesis. Time must be cited on a 24-hour basis, standard time. Abbreviations must follow common usage. Dates should be cited as example: 4. IV. 1979 (day-arabic numberal; month-Roman numeral; year-arabic numeral). Numerals must be used before measurements (5mm) or otherwise up to number ten e.g. (nine butterflies, 12 moths).

Title Page: All papers must have the title, author's name, author's address, and any titular reference and institutional approval reference, all on a separate title page. A family citation must be given in parenthesis (Lepidoptera: Hesperiidae) for referencing.

**Abstracts and Short Papers:** All papers exceeding two typed pages must be accompanied by an abstract of no more than 300 words. An additional summary is not required.

Name Citations and Systematic Works: The first mention of any organism should include the full scientific name with author (not abbreviated) and year of description. New descriptions should conform to the format: male: female, type data, diagnosis, distribution, discussion. There must be conformity to the current International Code of Zoological Nomenclature. We strongly urge deposition of types in major museums, all type depositions must be cited.

References: All citations in the text must be alphabetically listed under Literature Cited in the format given in recent issues. Abbrevations must conform to the World List of Scientific Periodicals. Do not underline periodicals. If four or less references are cited, please cite in body of text not in Literature Cited.

**Tables:** Tables should be minimized. Where used, they should be formulated to a size which will reduce to 4 x 6½ inches. Each table should be prepared as a line drawing or typed with heading and explanation on top and footnotes below. Number with Arabic numerals. Both horizontal and vertical rules may be indicated. Complex tables may be reproduced from typescript.

**Illustrations:** Color must be submitted as a transparency (i.e., slide) ONLY, the quality of which is critical. On request, the editor will supply separate detailed instructions for making the most suitable photographic ilustrations. Black and white photographs should be submitted on glossy paper, and, as with line drawings, must be mounted on stiff white cardboard. Authors **must** plan on illustrations for reduction to the 4 x 6½" page. Allowance should be made for legends beneath, unless many consecutive pages are used. Drawings should be in India ink at least twice the final size. Include a metric scale or calculate and state the actual magnification of each illustration as printed. Each figure should be cited and explained as such. The term "plate" should not be used. Each illustration should be identified as to author and title on the back, and should indicate whether the illustration be returned.

**Legends** should be separately typed on pages entitled "Explanation of Figures". Number legends consecutively with separate paragraph for each page of illustrations. Do not attach to illustrations. Retain original illustrations until paper finally accepted.

Review: All papers will be read by the editor(s) & submitted for formal review to two referees. Authors are welcome to suggest reviewers, and if received, submit name & comments of reviewers.

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COVER ILLUSTRATION: Scanning electron micrograph of Australian E. postica eggshell on nylon mesh (x42) by Barry Filshie. See J. Powell article, page 217, this issue.







